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Evaluation of nuclear decommissioning and waste management

A report commissioned by the
Department of Energy and Climate Change

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EVALUATION OF NUCLEAR DECOMMISSIONING AND WASTE MANAGEMENT

Final Report

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Executive summary

The history of nuclear decommissioning and radioactive waste management in the UK is one of protracted delay until the last few years. Until the setting up of the NDA in 2005 there had never been a concentrated national focus on the issue. An important consequence of these delays has been that the overall cost of managing the legacy of nuclear liabilities is substantially higher than it would have been had earlier opportunities been taken by government or the nuclear industry to get to grips with the problem.

Military decisions immediately after World War 2 led to an early civilian nuclear programme of gas-cooled reactors which were inherently more complex and expensive in terms of decommissioning and waste management than light water reactors. While it was difficult to avoid these early decisions, commitment to a second generation of gas-cooled reactors (the Advanced Gas-Cooled Reactors or AGRs) compounded the effects of earlier military-derived decisions and could have been avoided. Commitment to the reprocessing of spent fuel, which continued long after there was any evident rationale in economic terms, added substantially to the cost and complexity of managing the legacy.

In the decades up to the 1970s no serious thought was given, in the design of either military or civilian facilities, either to decommissioning or to the management of the more highly radioactive wastes that the nuclear enterprise produced. And when attention was given in the 1970s, it was focussed on commercial reactors, which had substantial remaining lives ahead of them - and the financial arrangements for their decommissioning were not supported by any cash provision. Meanwhile, especially at Sellafield and to a lesser extent at other sites, substantial legacies of nuclear materials from early military and civilian activity were subject to poor management practice and neglect, and began to deteriorate.

While there had been a strong recommendation to tackle long-term management of radioactive wastes in 1976, and some activity took place in the 1980s and 1990s, no serious progress was made. A fundamental problem was the structure of incentives: BNFL was tasked with making money while the UKAEA was primarily an R&D agency. Neither organisation therefore had an incentive to tackle a degenerating legacy.

The prospect of electricity privatisation in the late 1980s focussed attention on the legacy, especially for the prospective owners of reactors. There was to a degree focus as well on the facilities at Sellafield under BNFL management, but primary focus was on the liabilities for which BNFL's commercial customers would be liable. These processes led to a very large increase in the expected cost of managing the UK nuclear legacy, but no subsequent action. The financial provisions that were supposed to take care of reactor decommissioning were effectively lost and no new dedicated funding system took their place. The reprocessing of spent fuel, an exercise both costly and producing an unwanted primary product (plutonium), meanwhile continued.

However events in the 1990s provided the seeds of the improved approach that the NDA now embodies. The UKAEA, losing nearly all of its R&D function in the early 1990s, began to focus seriously on decommissioning its own estate, and developed a process of contracting out and competition that provided a model for later action. And when British Energy was privatised in 1996, a real fund to provide for liabilities was established, on a small scale, for the first time. But Sellafield's own liabilities, especially the so-called Legacy Ponds and Silos, were still neglected, and deteriorated further. The second real fund, BNFL's Nuclear Liabilities Investment Portfolio, was not used to deal with these large and increasingly hazardous liabilities: instead it accumulated profits and made a financial return for the company.

The turning point in this history of delay came with the publication of the Government White Paper *Managing the Nuclear Legacy* in 2002, the primary consequence of which was the setting up of the Nuclear Decommissioning Authority (NDA) and the start of a concerted effort to manage the legacy. The commitment of Government to a voluntarist approach to finding a site for radioactive wastes in 2006 marked a further step in legacy management. The 2002 White Paper recognised that managing nuclear liabilities cost effectively required financial flexibility and competent long term planning and consulted on a segregated fund or statutory segregated account (with preference for the latter) as innovative options in order to underline Government commitment, give the NDA greater flexibility and encourage competition for cleanup by giving market confidence that funding would be available.

A segregated route was not implemented and the NDA is subject to the standard public sector process of Spending Reviews and annual spending limits. However, spending is ring-fenced within the Department of Energy and Climate Change's budget, spending on decommissioning and waste management has increased significantly and spending on the highest priorities has been protected. Nonetheless, the NDA faces continuing operational and financial challenges, and there are further areas where targeted additional spending could yield further value for money savings. The long-term neglect of legacy facilities at Sellafield means that a very high proportion of the NDA budget needs to be spent there, involving high levels of 'hotel' costs as well as a systematic approach to tackling the legacy facilities.

There are necessarily constraints on NDA's desire to achieve greater flexibility and overcome problems of affordability. These ambitions have to be considered against the government's wider fiscal plans ,and competing demands for public spending. To meet its fiscal mandate, the Government must balance competing spending demands and manage expenditure through spending controls. Constraints on annual Government expenditure are therefore an important factor in determining the allocation of resources, and how much flexibility is possible.

Finally it is clear that Government has learned important lessons from this history: both the Nuclear Liabilities Fund (NLF) for British Energy liabilities and (especially) the proposed scheme to fund liabilities that will accompany any nuclear new build are much more robust than any previous funding scheme.

The main lessons that emerge from this study are as follows:

Provisions for liabilities

- Previous provisions for the cost of liabilities, although never adequate, were dissipated, and the funds and assets used for other purposes. Having a robust segregated fund to cover decommissioning costs aims to ensure that the funds are available when needed, and should build greater public trust. Government's approach to any new nuclear stations embodies this approach.

The level and flexibility of NDA funding

- Managing the NDA estate is characterized by high 'hotel costs' – the costs of simply maintaining sites safely and securely. This means that a marginal pound – if available to spend on decommissioning - will produce around twice as much direct liability discharge as the average pound. This has the potential to speed up completing the overall task. Accelerating decommissioning would be beneficial in net present value terms, by enabling hotel costs to be eliminated earlier.
- NDA also continue to face operational and financial challenges, both around the uncertainties inherent in such a large and technically difficult programme and in managing the volatility of their income from commercial activities. These challenges have a number of impacts, particularly on the efficient allocation of resources, and for how best to ensure contractors are given stronger incentives to innovate and provide value for money.
- In addition to the value for money case for acceleration in tackling the legacy, there is also the ethical case for not leaving a large liability for future generations. A pragmatic case would be to assist in legitimizing new nuclear build. However, these are highly constrained times for public spending, and the case for further acceleration will need to be balanced against other competing demands.

Reprocessing

- The continued commitment to reprocessing spent fuel has led to much higher costs of spent fuel and waste management than would have been the case if spent fuel storage had been introduced when it became apparent that costs for storage would be much lower than for reprocessing. Government's published expectation that reprocessing will be uneconomic in any future new-build programme is right. However the issue of the desirability of developing a new MOX plant as an effective management option for already-separated plutonium is a separate issue.

Effect of discounting

- Discounting always provides an in-principle rationale for delaying the tackling of decommissioning, because – all else equal - the present value of the task falls continuously the further into the future that decommissioning is postponed. Whilst the effect of discounting has been seen to influence delays to the decommissioning of reactors, I do not consider that overall it has been the primary driver – which has more often been affordability constraints in a situation where future expenditure yields no financial benefit. The high hazard facilities currently receive protected funding so discounting is not an issue where they are concerned, although discounting remains significant in assessing the business case for other projects.

Setting out the nuclear liability

- The NDA currently publish annual estimates of the discounted cost of future clean-up work. The most recent NDA annual report for the first time shows a range of possible values for the future liability.. Applying this approach to the undiscounted figures, as well as publishing them, would more clearly express the extent of the liability, and allow progress on decommissioning over time to be better demonstrated. Greater transparency might also help broaden public understanding of the scale of the legacy.

The Nuclear Liabilities Fund and new nuclear

- In addition to the arrangements for funding and tackling the existing legacy, the Nuclear Liabilities Fund (NLF) is an important (but different) model which has been designed to cover the costs of decommissioning the *current* fleet of AGR and PWR reactors in the UK. In developing an approach to tackling the liabilities generated by any *new* nuclear stations, it will be important to exploit synergies wherever possible with the existing NDA and NLF systems, and to ensure that the incentive structure for the new operators supports this. This is in line with the Government's current plans.
- Current policy requires the NLF to invest almost wholly in the National Loans Fund, offering relatively low returns but at the same time reducing the Government's overall debt in the short-term. This approach has implications for the likelihood that the fund will be able to cover all relevant liabilities in the longer term.

CHAPTER 1: INTRODUCTION

1.1 This study analyses the history of the decommissioning of nuclear facilities in the UK. This includes the management of radioactive wastes that result from both the operation and decommissioning of those facilities. The primary focus is on the buildings and materials under public ownership or control, mostly now owned by the Nuclear Decommissioning Authority (NDA). It also briefly considers facilities under private ownership, mainly the nuclear power stations owned by British Energy (BE, which is now owned by Electricite de France, EDF). It does not consider decommissioning and waste issues that will arise from any nuclear new-build power stations.

Box 1.1 – Evaluation Terms of Reference
MacKerron evaluation of UK approach to nuclear decommissioning and waste management.

To undertake an evaluation of the history of the UK approach to nuclear decommissioning, waste management and clean-up.

The evaluation will be led by Professor Gordon MacKerron. He will be able to draw on advice from within DECC, NDA and Shareholder Executive and other parts of Government as necessary and will be supported by a small team of DECC officials.

Professor MacKerron is asked to produce a report addressed to the Secretary of State by the end of August 2011. The report is intended for internal use but it should be written to allow the possibility of subsequent publication at some future date.

The report will cover:

- an historical account of decommissioning and clean-up activity in relation to the nuclear legacy sites for which the NDA is now responsible, including an account of the ownership and management structures relating to those sites;
- an analysis of the factors which have influenced the steps taken on decommissioning, clean-up and waste management, and the impact this has had on overall costs and value for money; and
- what lessons can be learned for the future of decommissioning, clean-up and waste management relating to the nuclear legacy for which the NDA is currently responsible.

The evaluation will be primarily a paper-based exercise, making full use of the extensive material in the public domain including NAO reports, White Papers, and financial reports. However, he will be able to draw on internal expertise and that of retired officials, and others as appropriate.

1.2 A variety of terms is used to describe the subject-matter of this study. The accounting term '**liabilities**' is frequently used to describe the financial scope of the tasks required. A liability is a cost, but one which is distinguished from a standard cost by the expectation that it will be met some time in the future – in the case of decommissioning and waste, often a long time in the future, when no obvious future income stream will be available to meet it. The term '**clean-up**' is used to encompass the activities involved in discharging the liabilities. Finally, the notion of '**legacy**' is also often invoked to capture the idea that there is a long history of the generation of nuclear materials to be managed, and that there is no choice about the need to find suitable management solutions. The idea of legacy also distinguishes the subject matter from issues of decommissioning and waste that will arise if decisions are taken to build new nuclear power stations.

1.3 The work undertaken for this report has mainly involved analysis of public domain documents. However it has been usefully supplemented by a substantial number of valuable interviews with people engaged, now or in the past, with decommissioning and waste management. These people have affiliations in Government, the nuclear industry and the regulatory community and my thanks are due to all of them for sharing their experiences and knowledge. I have drawn on their ideas but have not quoted any of them. I have also had excellent co-operation in undertaking the work from civil servants in DECC and the Shareholder Executive of BIS and a steering Group, chaired by Craig Lester, set up to advise on the project's progress. Special thanks go to Celia Frank of DECC and Roger Cotes of the Shareholder Executive for their extensive and highly effective work in assisting me in the analysis and preparation of the study. However I am alone responsible for the contents of this report, and opinions expressed are therefore my own.

1.4 The starting point is a chronological analysis of the emergence of decommissioning and waste issues, going back to the end of World War 2. Chapter 2 to 5 are of this type and the main interest in the history is to explain how past decisions have led to the expensive and complex problems involved in contemporary liabilities management today. Chapter 6 gathers together information on the management of decommissioning funding over the period up to the break-up of BNFL. Chapter 7 resumes the historical account in the present century. Chapter 8 provides an analysis of the issues that emerge from these earlier chapters, while Chapter 9 summarises the main lessons that can be learned from the history. Readers will find some repetition of material as between Chapters 4, and 6 to 8. The context and level of detail where this repetition occurs are however different, and editing out all repetition would have led to incomplete narratives in each of these three chapters.

CHAPTER 2: THE ESTABLISHMENT OF THE BRITISH NUCLEAR INDUSTRY 1945-1970

- The military drive for plutonium production, together with the drive for nuclear energy as a national priority, meant that the programme was pursued without being subject to justification in economic terms, and without the scrutiny applied to other public spending. The resulting Magnox technology produced large amounts of waste and the reprocessing of spent fuel added to waste volumes and costs.

- The adviser to Government on nuclear energy in the 1950s was the UK Atomic Energy Authority (UKAEA). This was established to promote a home-grown nuclear power industry via research and prototype development, and then contracting out building reactors. Reliance on an organisation with this mission meant Ministers' advice on the relative merits of different variants of nuclear power and coal came primarily from an organisation with purely nuclear interests. Analysis of the first reactor programme costs was geared to favour nuclear over coal.

- The UKAEA had a conflict of interest in assessing different reactor designs. The choice of reactor for the second nuclear power programme was ostensibly subject to competition, but in reality the choice was weighted in favour of the British Advanced Gas Cooled Reactor (AGR) design. The 1965 decision in favour of the AGR meant that the decommissioning and waste management burden was greater than if light water reactor technology had been chosen - and the continuing reprocessing commitment also led to poor value for money in terms of waste management.

- These factors continued to exert an influence as the British nuclear power programme developed, and led to British nuclear power being more expensive, both in comparison to other energy sources, and relative to some international nuclear comparators.

- The other, lesser, driver was energy security. Nuclear power, and the goal of a fast breeder reactor (FBR) were seen as the route to underpin economic revival.

- There is no indication that decommissioning or radioactive waste management were considered at the time. Significant volumes of radioactive waste were stored in ponds and silos at Sellafield without consideration of future retrieval and disposal, resulting in the difficult and costly challenges seen today in dealing with what are now high hazard facilities.

Introduction

2.1 In the immediate post war period, Britain aimed to be a global leader in the development of nuclear power. The first commercial nuclear power station in the world was opened by the Queen at Calder Hall in 1956, and in the 50s and early 60s the UK had a greater nuclear electrical generating capacity than any other country. In the early post-war years, spending by the UK Government on nuclear research rivalled that of the United States. However while the UK was first to establish commercial nuclear power, the power generated was significantly more expensive than that created elsewhere, particularly in the US.[1]. Other countries did not adopt the gas-cooled technology developed in the UK.[2] For purposes of this study, it is particularly significant that throughout the period covered by this chapter, decommissioning and waste were not issues considered in taking decisions on nuclear power. Source materials consulted are notable for not mentioning the subject. This lack of consideration was symptomatic both of a shorter term and sometimes minimalist environmental perspective and of the priorities of decision makers being elsewhere. However, the decisions taken did have significant implications for the future costs of the decommissioning programme.

The military origins of the British nuclear programme

2.2 The perceived successes and failures of the UK nuclear power industry stemmed from the same cause. The initial development of nuclear power was driven by a military imperative to produce plutonium[3]. It was then pushed forward by what Duncan Burn has described as a ‘wave of nuclear euphoria’,[4] in which cheap nuclear power was seen to represent the future, and where it was thought Britain needed to be at the forefront. There was simultaneously

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[1] See Burn, Duncan, *The Political Economy of Nuclear Energy*, pp. 109-115 for comparison of the development of British and American systems. Williams, Roger , The Nuclear Power Decisions, charts the growing disillusionment of the CEGB with the AGR relative to Light Water Reactor designs, pp. 208-230

[2] Williams, Roger *The Nuclear Power Decisions* – p. 122 – 124.

[3] Hall, Tony, the *Politics of Nuclear Power*, p. 9

[4] Ibid. p.50. See also Williams p.17

major concern that conventional sources of power, primarily coal, would prove insufficient to meet future energy needs.

2.3 The priority of successive Governments was, therefore, to establish a home grown nuclear industry. The result was that in the early years of the UK nuclear power programme, nuclear power was a national strategic priority, pursued without being subject to the need to justify itself in economic terms, and without being scrutinised in the manner of other national expenditures[5]. The industry was driven by central planning. Speed, and the Government's assessment of strategic necessity, took precedence over value for money considerations and competition.[6]

2.4 In 1946 the United States Congress passed the McMahon Act, forbidding cooperation with foreign powers in either civil or military nuclear power. This ended the period of joint working which had marked the Manhattan project.[7] From this point the establishment of an independent British nuclear deterrent was a priority. Each of the subsequent steps taken in the UK in the late 40s and early 50s was designed to meet military requirements, with civil benefits in generating electricity seen as a useful by-product.[8] Christopher Hinton, one of the leading figures in nuclear energy at the time, wrote that 'from 1946 to 1954 atomic energy was a defence industry, hence speed was vitally necessary and great risk of failure had to be accepted.'[9] The Windscale Piles were established as the fastest way to develop plutonium for the UK's military programme.[10] The construction of the world's first 'commercial' plant at Calder Hall was in fact entirely funded by the Ministry of Defence – despite the Central Electricity Generating Board (CEGB) having initially expected to provide a contribution. The imperative to produce plutonium for the military programme dictated the choice of approach to

[5] Hall, p .9.
[6] The analysis of how the structure of the UK nuclear industry shaped the decisions which were made, and led to poor cost-effectiveness is set out in Duncan Burn's *The Political Economy of Nuclear Energy*, op. cit.
[7] Hall, p. 22.
[8] Hall, p. 42.
[9] Hall, p. 11.
[10]Hinton described the Windscale Piles as 'monuments to our initial ignorance.' Hall, p.24.

building the Calder Hall station – and the choice of the Magnox gas cooled, graphite moderated design, rather than a heavy or light water reactor.[11] The effect was that, for reasons justified in the context of the over-riding military objective, the early decisions in the development of nuclear power were not taken on the basis of achieving a cost-effective way of generating electricity.

2.5 The military aspects of the nuclear project also resulted in a lack of financial scrutiny and challenge to the decisions taken in the early years of the programme. The Cabinet rarely discussed nuclear energy, and when it did it was more often in the context of controlling nuclear proliferation, rather than its implications for UK power generation. Nuclear power was taken outside of normal governance channels: the Prime Minister was advised on policy directly by a separate committee of officials who operated outside the Ministry of Supply. The costs were concealed within the Ministry's budget. When Churchill returned to power in 1951 he discovered that over £100 million had been spent on the programme.[12]

The establishment of the UK Atomic Energy Authority, and its relationship with the Central Electricity Generating Board

2.6 The establishment of the Atomic Energy Authority (UKAEA) in 1954 was critical to entrenching the special status that the development of nuclear power had acquired through its military origins. Lord Cherwell, Churchill's adviser on nuclear power, considered that nuclear industry needed to be set loose from the risk of being 'petrified' under the control of the Civil Service: 'only men used to tackling large industrial development' could handle such a programme.[13]

2.7 While the establishment of a separate authority resembled the approach taken to governing other nationalised industries, it is notable that

[11] Hall, p. 42.
[12] Hall, p. 29.
[13] Hall, p. 44.

nuclear power was held separate from other sources of electrical generation – governed by the CEGB in England and two Scottish utilities. The UKAEA's raison d'être was the promotion of a homegrown, nuclear power industry, and in the 1950s it was the primary adviser to Government on atomic energy. Ministers had no other authoritative source of independent advice to turn to. Writing in 1967, Burn argued 'Ministers have on occasion identified themselves so closely with the policies and decisions of the UKAEA that they have seemed like its public relations officer.'[14] Furthermore the UKAEA was not just an adviser to Government, it directly carried out the UK's nuclear research and development. In so doing, it developed the prototype reactors which it then contracted to British nuclear consortia to build. The result was that the UKAEA was not an even-handed judge between different technologies of nuclear power – it showed evidence of being institutionally committed to promoting the results of its own research programmes[15].

2.8 There was on occasion tension between the UKAEA, which controlled the nuclear power technology, and the Central Electricity Generating Board (CEGB) as the main purchaser. In 1955 the latter had been reluctant to order new Magnox plants until the first at Calder Hall had been proven. However, in the early years of the nuclear programme, it was the UKAEA that had the political upper hand. It was not until 1960 that the CEGB was able to exercise a decisive influence, succeeding in scaling back the target for nuclear generation capacity from 5,000 MW to 3,000MW.[16] While in retrospect, tension between the two organisations might be seen as a constructive check and balance on the development of the power programme, at the time politicians saw it as a matter of concern. By the mid 1960s, the pressure was for the two organisations to work closer together, with joint membership of their boards.

[14] Burn, p. 114.
[15] See Burn,op. cit.. p.13 and G.MacKerron, H Rush and A J Surrey 'The Advanced Gas-Cooled Reactor: a case study in reactor choice', *Energy Policy*, June 1977 for more detailed evidence. In the assessment of designs for the Dungeness B station only UKAEA staff assessed the reactor core; and the AEA made a new design of an apparently cheaper fuel rod cluster available to the consortium (APC) which won the competition.
[16] Hall, p.55. The CEGB found the UKAEA staff 'arrogant and unwilling… to accept advice on even the more conventional electrical side of nuclear power station design'.

Visions of the future

2.9 While the immediate imperative for the nuclear programme was to produce plutonium for military purposes, successive Governments also saw nuclear power as representing a route to ultimately producing cheap power to sustain British economic prospects and help UK exports. The fast breeder reactor (FBR) was the ultimate objective, as it would drastically reduce uranium use and in principle produce more fuel than went in to it – one estimate suggested that with a FBR, the entirety of the UK's electricity needs could be catered for by as little as 10 tons of uranium per year[17].

2.10 Almost as important as the positive vision however, was the threat that existing sources of power would be insufficient, and that nuclear power would be the only solution. The experience of power cuts during cold winters, with concomitant damage to British industry, prompted a sense of urgency about the need for energy security. Further, it was projected that the production of coal in the UK could not keep up with the demand for electricity. Nuclear power represented a home-grown route to achieving energy security. Unchecked enthusiasm was not universal. While the Advisory Committee on Scientific Policy reported that the cost of electricity generated by nuclear means would be just under two thirds the cost of coal, several members voiced concern that this estimate might be significantly over-optimistic**.**[18]

The development route selected makes British nuclear power more expensive

2.11 The rapid pace of the UK nuclear power programme after the war contrasted with that in the United States. In the US in the 1950s, the Atomic Energy Committee initiated a five year programme to test 5 types of reactor which it saw as 'giving promise for civilian power application.[19] Each of these was initially tested using small prototypes, rather than full scale plants. In

[17] Hall, p. 34
[18] Hall, p. 33.
[19] Hall, p. 17.

1955 it moved on to larger prototypes, with several different systems. In Britain, the approach was very different. Calder Hall, the first nuclear power station to be connected to a mains electricity grid was initiated in 1952 – based on a prototype, graphite moderated plant at the research facility at Harwell. In 1955 – a year before Calder Hall was completed - it was decided to expand the programme to build a further 12 power stations by 1965, with the initial reactors following the Calder Hall Magnox design.

2.12 In making the case for the first reactor programme, the analysis was conducted in ways that systematically led to the conclusion that the cost of nuclear power appeared competitive with more conventional sources like coal. It was decided that nuclear power plants would be assessed on the basis of their providing the base load of electricity, running continuously, while coal was evaluated on the basis of plants being turned on and off[20]**.** Secondly Government accepted that an allowance should be made – in practice a substantial allowance - for the value of plutonium generated through the power programme, which could be used in future FBRs. Even on the basis of assessments available at that time, FBRs were still some way from being developed. Subsequently the FBR programme was abandoned,[21] and Government consulted in February 2011 on approaches for managing the plutonium generated.[22]

2.13 The manner in which the 1955 White Paper *A Programme of Nuclear Power* tilted the balance in favour of the Magnox programme was symptomatic of two factors. The first was the extent to which the UK Government saw nuclear power as being a long term strategic priority for the UK. Secondly, there was the strength of the position of the UKAEA in advising Government while also having a major stake both in the expansion of the UK nuclear industry and in the technology which it had developed.

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[20] Hall., p. 53
[21] Hall, op.cit. p. 54.
[22] DECC, *Consultation on the Management of the UK's Plutonium Stocks*, February 2011. http://www.decc.gov.uk/en/content/cms/consultations/plutonium/plutonium.aspx

2.14 In 1957 it was decided to triple the total generating capacity of the programme to 5,000 – 6,000 MW, all of it from Magnox reactors. However, the first Magnox plants were more expensive to build than anticipated. At the same time the comparative cost of coal power fell significantly. Christopher Hinton, who led the UKAEA's production division, but who by then was chair of the CEGB, told a House of Commons Select Committee that nuclear power was 40% more expensive than a conventional equivalent[23]. This led in 1960 to the nuclear power programme being scaled back to 3000 MW (see para. 2.8), of varying levels of installed capacity and different detailed designs. It was also acknowledged that the Magnox power programme was never likely to be competitive with conventional power stations.

2.15 The UKAEA responded by developing its prototype for a new, gas cooled reactor, the Advanced Gas-Cooled Reactor (AGR), which reached full power in 1963. Government was initially expected simply to endorse a new nuclear power programme, based on the AGR. However, in the early 1960s the American Boiling Water Reactor was developing rapidly and GE claimed to be able to build plants capable of competing with conventionally generated energy. In April 1963 a White Paper announced the intention to seek bids for a second generation of nuclear power stations, allowing competition between AGRs and 'proven designs of water moderated reactors' of US types. However, while this appeared to show a readiness to test UK reactor designs against those overseas, the assessment panel consisted of a team of engineers and scientists from the Central Electricity Generating Board, and from the UKAEA – which had designed the AGR system. No experts with knowledge of the American alternative were included. The cost of the versions of American plant considered in the tender were 80% higher than the cost of a plant then being constructed at Oyster Creek in the US – in part due to the exacting specifications set out by the UKAEA. There were subsequently complaints from the other tenderers that the winning consortium – APC, which had submitted the AGR bid - had been allowed to modify their tender, while in

[23] Hall, p.70

effect those consortia submitting American designs had been required to propose models which were out of date.[24]

[24] Williams, pp. 138-141 and MacKerron et al. op. cit. See also footnote 10 above .

Box 2.1 – Decommissioning nuclear reactors and other facilities

Decommissioning is the process of returning nuclear sites to unrestricted or brownfield alternative uses. Following IAEA definitions, there are three stages to decommissioning a **nuclear reactor**:

Stage 1	Removal of spent fuel from the reactor core, after shutdown (storage with surveillance);
Stage 2	Some dismantling followed by care and maintenance (restricted site release)
Stage 3	Dismantling of the reactor core and clearance of the site (unrestricted site release).

The second and third stages can in principle be carried out at any time after Stage 1, subject to operator practice and safety considerations. The UK strategy since the 1980s has been to delay the final stage by approximately a century, officially to gain benefits from the decay of radioactivity.

There is a range of **other nuclear facilities**, including sites for fuel production, reprocessing, and waste disposal. The site at Sellafield, for example, comprises the various stages of the fuel cycle (as well as two reactors). Generally, their decommissioning will involve post-operational clean out (removing fuel and other radioactive materials or hazards); initial decommissioning (removal of easily dismantled contaminated parts); care and maintenance (allow radioactive materials to decay); waste characterisation (defining waste materials and their disposal route); decommissioning and dismantling (removal of all process plant and equipment); demolition of the structure; and remediation of land and water to meet an agreed end-state for future use.

Decommissioning always produces radioactive wastes of various types and an important part of the decommissioning 'cycle' is the packaging and emplacement of these materials in suitable long-term waste management facilities.

Decommissioning - not a consideration

2.16 Throughout this period decommissioning was not an issue visibly considered by decision makers, and no provision was made for its future costs or for those of wastes more generally. So, for example, while the first generation Magnox power stations were initially projected to have a lifespan of 20 years, apparently no thought was given to what would be done with the facilities once they ceased operation. Primary sources from the whole of this period do not discuss decommissioning.

2.17 During this early period significant volumes of spent fuel and nuclear waste were stored in ponds and silos at Sellafield, without consideration of how the material might be permanently disposed. One of the impacts of decommissioning not being a priority has been that radioactive materials have sat in ponds for so long that they have formed sludges, making the task of clean-up hugely more complex and expensive than if it had been addressed at the time. These legacy storage ponds and silos are now regarded as a high hazard as a result of long neglect and deterioration both in the materials and in their containing buildings. Making them safe, removing the material and decommissioning the facilities is now considered a national priority.[25] The Sellafield site licence company is working on a series of bespoke projects to extract radioactive material from these ponds and silos. These projects are needed either because the storage facilities were not designed with a view to extraction, or because the facilities to remove the stored material were left to fall into disrepair. In retrospect this clearly represents a significant failing in the thinking of the period. In the context of the time, it is also worth remembering that environmental and safety standards were much lower, in common both with other industries and other countries.

2.18 The scale of the nuclear liability faced by the UK is to a large degree shaped by this period, and the extent to which it is larger than other countries may to some degree be due to the UK having been a nuclear pioneer – and having developed a programme before better standards of design and waste storage became standard. The lesson is that in considering the development of a nuclear programme it is critical to plan for the long term, and to design facilities with a view to their decommissioning as well as their operation.

[25] Spending on these facilities was protected in the 2010 Spending Review Settlement – HM Treasury, *Spending Review 2010*, p. 62.

BOX 2.2 - International comparisons

The scale of the decommissioning challenge facing the UK relative to other countries with a nuclear history is largely the product of two factors: (1) the decision, stemming from the military origins of the programme, to follow the developments of the UKAEA's research programme to adopt gas cooled reactors, rather than water cooled; and (2) the poor standard of storage facilities – primarily in what are now described as the Legacy Ponds and Silos at Sellafield as well as a shaft at Dounreay. While the Legacy Ponds and Silos are now by some distance the highest cost element of the nuclear legacy, the scale of the problems has also been influenced by the volume of radioactive waste generated (which would have been significantly lower had water-cooled reactors been used), by the susceptibility of Magnox spent fuel to corrosion when stored in water, and by a continued commitment to reprocessing AGR fuel beyond the time when it was economic.

A study by the Nuclear Energy Agency of the OECD in 2003 compared international decommissioning strategies and costs.[26] This showed that gas-cooled Magnox reactors (based on examples from the UK, Italy and Japan) were expected to produce around 100 tonnes of radioactive waste in the course of the decommissioning process per MW of generating capacity. This compared to 10 tonnes or less for most water cooled reactors. The greater volume of waste is the result of both Magnox reactors' greater physical size, and the need to dispose of large amounts of graphite. The result is that Magnox reactors are very much more expensive to decommission than any comparator – on the NEA study basis, the cost of decommissioning a Magnox reactor was estimated at more than $2,500 per kW of generating capacity, in comparison to less than $500 for any other design of reactor (a PWR was estimated at an average decommissioning cost of $320 per kW of capacity). The high cost of decommissioning Magnox reactors extends to the two reactors exported by the UKAEA; the estimated cost of decommissioning the Italian Latina reactor is $3,248 per KW of capacity, while the figure for the Tokai reactor in Japan is $4,470.[27]

The design of Magnox reactors also illustrates how planning for decommissioning is critical to cost control. Light-water reactor pressure vessels, in addition to being much more compact than Magnox vessels, are designed so that the top can be removed, giving direct access to the full diameter of the reactor, which enables all of the fuel to be removed in a short period. This has meant that defueling at the end of a reactor's life becomes routine. In contrast Magnox reactors are not only of much larger size, but also have a non-removable top, with only limited access designed into the reactor vessels for fuelling and defuelling purposes through small diameter penetrations requiring defueling machines which are not always available for

[26] *Decommissioning Nuclear Power Plants*, OECD 2003 (2001 figures).
[27] Definitions of what constitutes decommissioning activity vary – for example in Japan it is accepted that the end state of the site can be one which is suitable for new nuclear construction, whereas in the UK and Italy the requirement is that the site should be suitable for unrestricted use. However these variations appear not to affect the broad thrust of the evidence on cost comparisons.

100% of the time. The result is that the defuelling process in practice takes a number of years – which is particularly significant as the period over which the fuel remains in the reactor has the highest 'hotel' costs.

The NEA study also shows that the UK intends to defer decommissioning of its reactors for substantially longer than is commonly the case overseas. It reports that the average time from reactor shut down to complete decommissioning of a UK gas-cooled reactor is expected to be in the region of 100 years, which compares to an average internationally of around 20 years for a PWR. The rationale for the delay in addition to the affordability constraint implied by the high cost of decommissioning is officially that radiation levels within Magnox reactors are predicted to reduce to levels which allow direct human access within 70 to 90 years of shutdown, whereas in light water reactors the delay would need to be significantly longer to allow direct contact and here instead the intention is to decommission using remote equipment. However this contrasts with the approach to the Italian Latina Magnox plant, where Government policy is that decommissioning should be complete by 2024. However it is a deadline that has already slipped (from 2020) and final decommissioning is contingent on the availability of a repository. All of these figures represent targets or ambitions rather than achieved results – so the timescale in all the countries cited, apart from the UK, may well reflect a degree of optimism bias.

Conclusion

2.19 A number of criticisms can and have been made of the UK nuclear power industry in the 1950s and 60s.[28] First, the UKAEA had dual and conflicting roles as simultaneously technology developer and main Government adviser on nuclear power. This, together with the lack of scrutiny applied to it, meant that Ministers did not have access to balanced advice on the relative merits of different types of nuclear power and of alternative power generating options. Second, because the UKAEA was itself responsible for researching and developing models of nuclear reactor, it had a vested interest in their success, and was not a balanced judge of whether they should be adopted. While there was apparent technology competition to build a second nuclear programme, leading to the decision in favour of AGRs, the restrictions placed upon the competition produced a very expensive outcome. Third, and as a result of these factors, research in the UK (almost entirely led by the UKAEA) pursued a narrow course, following a route initially prescribed by the requirements of the defence industry, rather than proceeding to test a variety

[28] See Burn, p. 100.

of reactor systems. This can be understood in the context of the need to develop a source of plutonium rapidly but in the long term, continuation of this approach meant that British nuclear development followed the narrow course of the UKAEA's research, and new UK designs were not thoroughly tested against potential alternatives. This narrow approach was to have major consequences for the cost and complexity of the subsequent task of decommissioning and waste management.

CHAPTER 3 – THE UK ATOMIC ENERGY AUTHORITY AND BRITISH NUCLEAR FUELS LIMITED: CONFLICTING MISSIONS

- In early-mid 1970s, AEA's and BNFL's primary missions were not focussed on managing liabilities.
- AEA was a civilian nuclear R&D agency in thermal, fast breeder and fusion systems. BNFL was a publicly owned plc focussed on commercial activities associated with the fuel cycle (mainly reprocessing spent fuel).
- In the late 1980s, both were required, because of increasing general environmental concern and deterioration in some early plants, to take on some responsibility for liabilities management, but were not given the incentive structure to do this effectively, especially in the case of BNFL.
- There were also specific issues: for BNFL over discharge levels leading to international pressure and for AEA around the rundown of its non-fusion activities and making early R&D facilities safe.
- The Government's objective for BNFL was to maximise over time the return to its shareholding, with quantitative performance targets set by the Department of Energy. No targets were set for decommissioning or waste management.
- BNFL remained largely conflicted between making money and carrying out clean-up. In contrast, the ending of virtually all AEA research funding by 1994 reduced conflict and meant it became a liability management agency, developing useful ideas for managing liabilities via competition and contracting out.

Introduction

3.1 In 1971 the Atomic Energy Authority was split up. It had previously taken primary responsibility for UK nuclear research (including military applications), reactor design, fuel production and reprocessing, alongside the operation of two Magnox power stations. The MoD took over military functions and British Nuclear Fuels was established as a public corporation responsible for commercially exploiting the full range of fuel cycle processes, including fuel manufacture, and reprocessing. BNFL also took responsibility for two Magnox power stations – Calder Hall at Sellafield, and Chapelcross in Dumfries and Galloway, and the management of the legacy facilities at Sellafield. The UKAEA was tasked with driving forward the UK nuclear sector through research and development, acting in support of commercial partners. The motivation was a desire to split off military from civilian activities and to separate out activities that were in principle profit-making from ongoing R&D.

The objectives set for BNFL and for UKAEA

3.2 BNFL's focus was unambiguous. Its primary mission was to make a profit, and there was an expectation – even in an era when nationalised industries were standard – that a significant proportion of it might be sold to private investors. Secondly it was to be a national champion of nuclear power, one of the few companies that could claim to be capable of offering a service to cover every stage of the nuclear fuel cycle. The ambition was not just to run an efficient UK business, but to succeed where the UKAEA and its predecessors had failed, by developing a worldwide business, providing fuel cycle technology and services to overseas customers.

3.3 The company's first annual report acknowledged, however, that a major export business would not be established immediately and 'that [BNFL's] main dependence for some years to come will be on the home market.' In fact at the time of its creation 60% of the company's turnover was in 'the fuel cycle business with two customers, the Central Electricity Generating Board and the South of Scotland Electricity Board;' while 30% consisted of 'sales and services to the UKAEA and electricity sales'.[29]

3.4 In the early 1970s the UKAEA continued to see itself as the overall guardian of the UK's nuclear mission, having 'stewardship on behalf of Government, in atomic energy affairs generally.'[30] Despite the creation of BNFL, it retained 'the preponderant share of the country's resources, both human and material which are devoted to the development of atomic energy for peaceful uses.' In fulfilling this role, the UKAEA had two more specific functions, supervising 'research and development on aspects of nuclear power which are of concern to the community generally', and 'providing continuous research and development support for the British nuclear industry.' The first of these two roles indicated a greater concern than had previously

[29] UKAEA, *Annual Report and Accounts, 1973*, p.7.
[30] UKAEA, p.7.

been emphasised with ‘safety and environmental matters’. The second included both technical support for improving the efficiency of existing UK reactors, and, of particular significance in terms of the Authority’s ambitions, developing new reactor systems. Among these latter, the main objective continued to be the development of the FBR, which it envisaged would become available commercially in the 1980s, and would ‘supply a major part of the UK’s electrical power by the end of the century.’[31]

The growing acknowledgement of the significance of liabilities management

3.5 In the 1970s neither BNFL nor the UKAEA made more than a passing reference to liabilities management in their accounts, and they did not make any explicit provisions for decommissioning. BNFL did make a provision for costs which it could foresee arising in the medium term as part of the fuel cycle – £13 million in March 1977 to cover the cost of the vitrification of waste products created since the incorporation of the company in 1971. However it explicitly set out that ‘provision [would not] be made for the ultimate disposal of wastes until appropriate routes approved by the Regulatory Boards have been established’.[32] BNFL’s claim in relation to decommissioning was broadly that the liabilities fell on its customers but in 1978 it acknowledged that not all of the costs could be passed on in this way. In particular, it admitted that it would be financially responsible for the decommissioning of the two Magnox stations it owned at Calder Hall and at Chapelcross.[33]

3.6 BNFL’s approach was not to make any provision until an assessment of the costs could be established, and this was not attempted until 1978-9. The first provision for the cost of decommissioning was subsequently made in 1980, with £35.3 million marked up in BNFL’s accounts for addressing its two Magnox power stations. This figure steadily rose throughout the 1980s – reaching £72.2 million in 1986. However, while this represented an acknowledgement of a liability, we have not seen any evidence of systematic analysis or planning of how it would be discharged, or when the actual work

[31] UKAEA, op. cit.
[32] BNFL *Annual Report, 1984-5.*
[33] BNFL *Annual report, 1978-9*, p.15.

would be carried out. BNFL's focus was on extending the life of its two Magnox stations, and prior to the late 1980s it does not seem to have given thought to the timeline that would apply to decommissioning the plants after they had ceased operation. The figure marked up in the accounts up until the late 80s was therefore only a rough estimate at current cost.

3.7 In 1987 BNFL carried out a more substantive evaluation of liability costs. This went beyond the two Magnox stations to consider the full range of facilities at Sellafield, covering 'plants still at the design stage and under construction as well as existing plants nearing the end of their useful life'. The review also included assessments of low level and intermediate level waste arising during the decommissioning operations.' BNFL also for the first time set out a timescale, albeit one which was still very generic and tentative, for performing the decommissioning works. The initial stage of the work involving 'decontamination of the plant and immobilisation of residual radioactivity' would be carried out 'as soon as reasonably practicable after the end of the plant's useful life' while the decommissioning work would be completed within 50 years for 'process plants' and 100 years for reactors. It seems likely that the start of this more comprehensive approach to estimating liabilities was largely due to the approaching attempt to privatise the CEGB and SSEB.

3.8 This assessment would have had significant consequences for BNFL's provision for decommissioning costs in its accounts. However, in practice the effect was much less significant than it might have been as for the first time the provision was made on a discounted basis. While the figure set out in 1987 increased from £72 million undiscounted to £135 million discounted, it in fact represented much more than a doubling in the scope of work anticipated.[34] This figure was still modest in relation to later estimates.

3.9 For the UKAEA the late eighties also marked the point at which it started to pay more serious attention to decommissioning. The area was not discussed at all in its annual reports prior to 1986, and no provision was made for meeting any costs. In that year the issue was brought to a head when the

[34] It is not possible to assess the full extent of the cost without knowledge of (a) the discount rate, and (b) the profile over which the spend was intended to take place.

Authority was made a Trading Fund, and was expected to operate on a more commercial basis. To coincide with its establishment as a fund it secured an undertaking from the Secretary of State (SoS) for Energy, accepting responsibility for the cost of treating and disposing of wastes and decommissioning plants established prior to that year. However, its understanding of what this liability might correspond to remained vague - in 1987 the Authority estimated that Government would need to provide '£20-30 million per annum for the foreseeable future' to meet the SoS commitment, in addition to a liability owed to BNFL, which in 1988 was estimated at £40 million. At this stage, the Authority was having its first practical experience of decommissioning – taking down the Windscale Piles, and starting to decommission the prototype AGR reactor at Sellafield.[35]

Governance structures and incentives

3.10 Prior to 1981 the Government's shareholding was owned through the UKAEA, and subsequently it was held by the Department for Energy. After the Department took over the shareholding, the main governance structure was through the requirement for the Government to approve the Corporate Plan and major capital projects. Through the approval of the Corporate Plan, the Department was able to set performance targets for the company.

3.11 Initially targets were based on volume of sales and profits per employee; the company then argued that as the majority of its business was undertaken on cost plus terms, the main performance aim should be to improve efficiency and reduce costs. From 1983 to 1986 the target was that BNFL should reduce specified costs in real terms by two per cent per annum, and overall controllable costs by one per cent in 1985-6.[36] In addition to these overall objectives, specific targets were set for individual capital projects. In 1989 a report for the National Audit Office on the governance of BNFL found that these targets represented 'a major step forward in introducing quantitative performance aims, and noted with satisfaction that during the previous two years the targets had been met'. From 1985 BNFL's targets were supported by a bonus scheme for board members, based on the Company meeting (a)

[35] UKAEA A*nnual Report, 1989-90*, p. 41
[36] Ibid, p. 16.

the medium–term financial target; (b) the production requirements of the home generating boards; (c) manpower below budget; and (d) relevant capital investment milestones. A review of BNFL's annual reports supports the view that current financial performance was therefore the main driver for the company. Chairmen and Chief Executives concentrated on explaining profitability and the level of dividend paid to shareholders - it was very rare for future liabilities to receive a mention.

3.12 In the 1980s BNFL therefore saw decommissioning as a future challenge, and one which was seen to apply primarily to the two Magnox power stations when they ceased operations – a date it hoped to postpone for as long as feasible. Similarly, other BNFL plants (especially the Magnox reprocessing plant) were largely still performing the functions for which they had been designed. While it is therefore not surprising that no targets were set for decommissioning, the risk was that without such targets there was no impetus for the company either to seriously think through and analyse the future decommissioning challenge, or to consider how future costs could be limited by steps taken in the current period.

3.13 BNFL did not appear to pay much attention to remediating the Legacy Ponds and Silos. Financially these were the responsibility of the MoD, and the CEGB and SSEB. BNFL saw their own role as to work on remediating these facilities only to the extent that these two other bodies were willing to finance such work and their experience was that these organisations were only willing to pay enough to allow the facilities to 'tread water'.[37] For these large and, as it turns out, troublesome liabilities, BNFL seemed unwilling to take any further initiatives.

[37] Interview evidence.

Increasing environmental and safety concerns

3.14 BNFL did have broader environmental concerns through, firstly, political pressure partly driven by international demands to limit emissions from Sellafield to the sea and, secondly, a general concern to promote the UK nuclear industry, which was threatened by public perception of safety risks following rising discharge levels.

3.15 A series of events, mostly external to BNFL, forced some increased interest in managing liabilities though the 1980s. The accidents at Three Mile Island (1979) and Chernobyl (1986) raised public perceptions of the risks associated with nuclear power and resulted in increased pressure on BNFL to be more aware of operational risks. Between these two accidents there was the Sellafield beach incident in 1983, where discharges to the Irish Sea led to the prosecution of the company. Through the 1980s BNFL spent substantial sums to reduce liquid discharges into the Irish Sea, for example on the SIXEP plant.

After the closure of its research programmes the UKAEA develops a greater focus on decommissioning, and contracts out delivery

3.16 In the late 1980s and early 1990s, funding for the UKAEA's research programmes was severely curtailed. As late as 1989, the inside cover of the UKAEA's annual report was a picture of Dounreay at night, with the caption 'fast reactors, tomorrow's power today'. A breakdown of the Authority's expenditure in that year makes no reference to decommissioning, with by far the largest proportion of its budget (27%) going to the fast reactor programme. The rest of the budget was divided in chunks of no more than 8% between different elements of the UK reactor programme and underlying research. By 1994 funding for the FBR programme was ended and the prototype FBR at Dounreay had been shut down. With the exception of continuing funding for nuclear fusion research, the UKAEA's raison d'etre effectively came to an end. The obvious new focus for the organisation was the management of the liabilities that its previous work had generated.

3.17 By 1997, when Arthur D Little (ADL) was commissioned to review the UKAEA's performance in managing its liabilities, the effect of this shift in focus was evident. The Authority adopted a contracting model in which it planned and controlled works carried out on its sites, but did not itself carry out decommissioning work, or provide associated support services. ADL were impressed with the organisation's contracting ability, reporting that it was 'ahead of the rest of the public sector in its approach… and compares favourably with the private sector'.[38] This improved performance was driven by senior management. However it took time for the more junior levels of the organisation to adjust to the new role and for new skills to be brought in, and the Nuclear Installations Inspectorate (NII) took the view that the UKAEA did not always have the technical skills to perform site licence functions to full effect, culminating in a temporary shutdown at Dounreay in 1998 after a contractor cut though the main electrical cable to the site.[39]

BNFL's focus remains on commercial activities

3.18 For BNFL, decommissioning and waste management did not become a driving issue for the company as a whole until a much later stage. In the late 1980s and early 90s, the predominant reputational issue for the company was bringing the Thermal Oxide Reprocessing Plant (THORP) into operation. This was its biggest capital project, and a major driver of the bottom line. The company failed to hit its profit targets for two years due to delays to the project.[40]

3.19 In the 1980s none of the company's divisions was focussed on decommissioning. BNFL was divided into four groups: Fuel Manufacture; Enrichment; Reprocessing Operations; and Reprocessing Engineering. Even by the mid 1990s, there was no group focussed on discharging BNFL's liabilities. Although BNFL did have a division focussed on Waste Management and Decommissioning by then, its primary focus was not the company's major liabilities at Sellafield or even in the UK, but BNFL's American decommissioning business BNFL Inc. Decommissioning at Sellafield was the

[38] *Quinquennial review of the UKAEA*, p.34.
[39] *History of the NII*, 2006 p. 21.
[40] BNFL *Annual Report* 1992-3 p. 6 and BNFL *Annual Report 1993-4*, p 3.

responsibility of ‘Spent Fuel Management Division’, the main focus of which was THORP, and the Sellafield MOX plant. Unlike UKAEA, BNFL did not seek to compete the management of its decommissioning tasks among outside contractors. While it did contract out construction work, the design and project management remained in house.[41] This may have contributed to a lack of focus on the cost of these activities and how they could be driven down, or more innovative approaches employed.

[41] Interview evidence.

CHAPTER 4: THE UTILITIES - DECOMMISSIONING LIABILITIES

- There was limited planning or financial provision by the public electricity utilities (CEGB and SSEB) for decommissioning their nuclear generating stations until the late 1980s.
- Sharp rises in cost estimates and provisions resulted from scrutiny ahead of electricity privatisation in 1989, from BNFL's reassessment of its costs to its utility customers and early experience of decommissioning Berkeley station.
- The scale and uncertainty of emerging estimates of the liabilities for the Magnox fleet led to their withdrawal from privatisation in July 1989, with AGR and PWR stations following in November 1989
- Cost estimates were subject to periodic escalation because of complexity, project appraisal optimism and risk of game changing events, e.g. rises in regulatory standards during the long time periods chosen in decommissioning strategies.
- The Deferred Safestore Decommissioning Strategy adopted in 1995 extended the period to final stage decommissioning and reduced discounted liabilities significantly. This strategy was developed in the context of Government pressure on Nuclear Electric (which took over CEGB's reactors after electricity privatisation) to reduce costs. Counter-arguments from regulators and environmental stakeholders in favour of dealing with liabilities earlier had no evident effect.
- The Government decided that a segregated fund, managed externally, would provide greater assurance for funding of British Energy's liabilities.
- Radioactive waste disposal was not seriously considered until the mid-1970s. Attempts by Nirex after 1982 to find and construct a disposal site for low and intermediate level wastes came to nothing and by 1997 there was an impasse in the development of policy in this area.

Introduction

4.1 This chapter explains the way in which the utilities (Central Electricity Generating Board (CEGB), South of Scotland Generating Board (SSEB) and later Nuclear Electric (NE), Scottish Nuclear (SN) and Magnox Electric (ME)) developed policies for decommissioning their nuclear power stations. These policies in general emphasised delay to the most expensive elements (reactor dismantling) for up to 135 years. There was also significant interplay between their approach to decommissioning and wider government policies, in particular privatisation of the electricity supply industries. The chapter outlines the provisions made to fund decommissioning through unsegregated internal funding from 1976 until the 1990s. It explains the reasons for the different route – a segregated fund - specified for British Energy when it was privatised in 1996. Further, it outlines the history of the attempt by NIREX to implement a repository for intermediate level waste.

4.2 The main theme of the chapter is the conflict between Government pressure on the utilities to make money (which was intense in the 1980s) and the ‘drain’ on their cash or accounts that expenditure or provisions for decommissioning would inevitably bring. The deferred decommissioning strategy adopted was publicly justified by the idea that delayed decommissioning would be cheaper due to radioactive decay but there was also a financial motivation. The application of even a low discount rate (2% real) meant that the required accounting provisions – given deferral for a century - were very small.

4.3 Decommissioning, defined narrowly, is the process of returning nuclear sites to unrestricted or brownfield alternative uses (see Box 2.1). The costs of disposing of the large quantities of waste created in decommissioning are included, conventionally, in the cost of decommissioning. The utilities also made some provisions for the decommissioning of BNFL fuel cycle plant used for Magnox and AGR operations.

4.4 The utilities’ strategies on the timing and scope of the later stages changed over time. The CEGB and SSEB were responsible, between 1976 and 1990, for developing policy and funding for decommissioning their own reactors. They owned nine Magnox power stations and seven AGR stations. The responsibility then passed to Nuclear Electric plc (England and Wales) and Scottish Nuclear Limited (Scotland) up to 1996 for AGRs/Sizewell B, while Magnox Electric in the public sector continued with responsibility for all Magnoxes (six operating stations and three that had already shut down). From 1996 British Energy (BE) took responsibility for all AGRs/Sizewell in the private sector, while Magnox Electric (ME),formed in the same year, became a subsidiary of BNFL from 1997.

Decommissioning provisions and strategy from the late 1970s to 1990

4.5 As Chapter 2 noted, there was no visible thought given to the decommissioning of nuclear facilities or associated funding before the mid-1970s. CEGB, which owned most of the nuclear power stations in England and Wales as well as the transmission system and other types of power station, made provision for the first time for long-term liabilities in its 1976-77 accounts. However, while these provisions corresponded to real additional charges on consumers, these were ‘internal unsegregated’ funds, invested in the business. They were effectively a form of cheap capital, and there was no cash set aside.

4.6 Provisions for decommissioning costs of the CEGB’s stations rose from £10 million in 1977 to £110 million (on a revised, current cost accounting basis) in 1981, when provision (£9 million) also started to be made for decommissioning of the BNFL-owned plants at Sellafield which would be used (£345 million for reprocessing spent fuel and waste storage and disposal)[42]. The annual provision was adjusted to allow for inflation, changes in expected plant lifetimes, for the estimated incidence of expenditure and the commissioning of new nuclear stations. The early estimates were based on mechanistic assumptions – that decommissioning might cost between 10% and 15% of the initial construction cost – and it was not until 1982 that the results of a three year study into the decommissioning costs of Dungeness A became available.[43]The 1982 study was used as the basis for all Magnox and AGR cost estimates up to early 1989.

4.7 Decommissioning Magnox was a unique task. The 1982 study set out the considerable technical uncertainties involved when no large commercial nuclear power station had been decommissioned together with the risks from future changes in regulatory conditions. However, despite these uncertainties, it provided quite precise estimates of constituent costs to the nearest £10,000.

[42] CEGB, *Annual Reports and Accounts*, 1976-77 to 1989-90
[43] *Decommissioning and Waste Management Topic Group report to the Nuclear Utilities Chairmen’s Group* (representing Nuclear Electric, Scottish Nuclear, BNFL and UKAEA) 1992

4.8 The estimated cost of decommissioning each station (at March 1982 prices) of Stage 1 was £20.7 million (over 5 – 7 years), Stage 2 £35.7 million and Stage 3 £212 million, if carried out 15-20 years from shutdown, giving an overall cost of nearly £270 million. The timing of Stages 1 and 2 expenditure was dictated essentially by the shutdown dates of the Magnox stations but there was a choice of short or long timescale for Stage 3. From the engineering point of view it was argued the task might be undertaken anytime from 10 to 100 years from shutdown and should be easier the longer it was deferred, reflecting the reduction in cost related to radioactive decay, greater experience and development of engineering methods.

4.9 Estimates of the costs of decommissioning the UK nuclear power stations increased significantly through the 1980s as a result of closer scrutiny during preparations for electricity privatisation in the late 1980s and technical experience from starting to decommission the Berkeley Magnox power station. The effect was to raise significantly the accounting provisions across the fleet of nuclear stations. There was therefore a strong incentive both to firm up and if possible slim down the estimates and thus the provisions made. CEGB and SSEB annual reports in the period up to 1990 said little on the strategies that lay beneath the accounting provisions, or on what detailed assumptions went into the funding numbers.

4.10 By 1988, the total provision had risen to £3.3 billion. During 1989, a number of further reviews of decommissioning costs were carried out and results from the more detailed study of Berkeley decommissioning became available. With this new technical information and under the scrutiny brought on by preparations for electricity privatisation the total provision increased sharply to £8.5 billion in 1989.The requirements for the flotation entailed the release of much fuller information and analysis than had previously been available so that potential investors could have a realistic view of the balance of assets and liabilities. The scale of the expected liabilities bill had become large in relation to the value of the generating assets in National Power which were intended to support them. This, and the rapid escalation in these liability estimates exacerbated uncertainty around whether these much higher costs were robust. This led to “cold feet” in the City, the electricity industry and in Government.

4.11 Among the most important components of the large increases in liabilities discovered in the run-up to privatisation were as follows: first, the anticipated costs of decommissioning an average Magnox station approximately doubled from £312 million to £600 million (undiscounted), mainly because of uncertainties attaching to a process that had yet to be commercially established; and second, once BNFL calculated the cost of their own decommissioning to the point of returning their sites to green field status, the total undiscounted bill escalated approximately eleven-fold, from £438 million to £4.6 billion (and BNFL’s cost-plus contracts meant it could pass through almost all this increase).[44]

4.12 There is a view that the uncertainty revealed by these cost escalations during preparations for electricity privatisation meant that the estimates could be influenced by the players’ interests in presenting ‘the facts’ to their benefit. For example, National Power, which was originally due to take on the nuclear power stations, had a clear financial interest in talking up these numbers, as they were the basis of the prices at which National Power argued that it would be willing to take on ownership of both nuclear assets and liabilities.[45]

4.13 In July 1989, the rapid escalation in the estimates of Magnox liabilities led to their withdrawal from electricity privatization.[46] In November 1989, the Government announced that the remaining AGR and PWR stations would also be withdrawn for similar reasons.[47] All nuclear power stations owned by the CEGB and SSEB would be vested into new companies (Nuclear Electric plc and Scottish Nuclear Ltd) which would not be floated with the rest of the electricity supply industry. At the same time, Government announced a moratorium on new build (subsequent to Sizewell B) for 5 years, and a review of nuclear policy by 1995.

[44] G MacKerron in J. Surrey (ed.), *The British Electricity Experiment: Privatization: the record, the issues, the lessons*, 1996, pp. 145-6
[45] Dieter Helm, *Energy, the State, and the Market*, 2003, p. 190
[46] *Hansard*, 24 July 1989, columns 746-8
[47] *Hansard*, 9 November 1989, columns 1175-83

Fossil Fuel Levy and the Non-fossil Fuel Obligation

4.14 The size of nuclear liabilities had driven the design of the structure of the new power generators – to bear the cost of the nuclear fleet and back-end liabilities would need considerable financial strength. So, despite the objective of increasing competition, generating stations were divided into only two companies in England and Wales, with the larger, National Power, taking 70% of the assets including all the civil nuclear reactors. When the nuclear stations were subsequently withdrawn from the privatisation, it was considered too late to restructure the generators to increase competition.[48]

4.15 For the internal unsegregated funding route to have any chance of working, the investments made with the provisions set aside since 1976 (in non-nuclear generation as well as transmission) should have gone to the nuclear companies. However, Nuclear Electric and Scottish Nuclear only inherited the nuclear part of the investments and these were, initially at least, loss-making. These losses meant that a new source of guaranteed income was necessary to keep Nuclear Electric 'cash-positive' and this took the form of the Fossil Fuel Levy (FFL). As an addition to NE's cash stream, this Levy also could help to pay for liabilities, but this was not its main purpose.[49]

4.16 The FFL was accompanied by a Non-fossil fuel Obligation (NFFO) on the regional electricity companies (RECs). They were obliged to buy all the electricity that NE made available. They collected the Levy from consumers, but paid only the standard wholesale price for nuclear electricity. The Levy varied annually but amounted on average to 10% on retail bills. Although renewable energy also benefited from the levy, the overwhelming bulk of the revenue went to nuclear, leading some to view it as a 'nuclear tax'. This 'nuclear tax' was not strictly new – customers had been paying for it under the old charging arrangements. In order to ensure the levy did not distort competition and to meet state aid rules, the measure was time-limited. It was due to expire in 1998, with the arrival of retail electricity competition.

[48] G. MacKerron 'Nuclear power under review' in J. Surrey (ed.), op. cit. pp. 146-148
[49] G. MacKerron op. cit. pp. 148-151

4.17 Separate arrangements were made for Scotland, where no Magnox reactors were still running and the two AGRs had relatively good operating performance. No levy was needed but the two Scottish utilities were required to buy all SN output at a price that was initially at a premium level but designed to fall by 1998 to the average English price established in a competitive market.

4.18 The FFL produced an average of about £1.2 billion annually for NE until privatisation of the AGRs and PWR as British Energy took place in 1996. To the extent that the Levy did fund liabilities, they represented the costs of reprocessing rather than decommissioning (all NE reactors were operational), and this absorbed just over 50% of the Levy proceeds to 1995.[50] Because NE succeeded in radically improving the operating performance of its AGRs, nearly £2.6 billion of surplus cash had accumulated in its books by 1996 and this was transferred to Magnox Electric.

Development of Deferred Safestore Strategy which postponed final dismantling and reduced discounted costs

4.19 As part of the preparations for the 1995 nuclear review, DTI asked NE to review the efficiency of its operations. The NAO[51] reported on the extent of potential Government liabilities for nuclear decommissioning, on how this was to be financed and the possible implications for the taxpayer. They argued that a primary objective of the Department should be to ensure that the companies minimise their decommissioning and other liabilities as well as the extent to which the Government might be called upon to meet them. Both Nuclear Electric and Scottish Nuclear were set the objective of reducing their decommissioning costs.

4.20 Following the review of alternative decommissioning strategies, Nuclear Electric proposed adopting a new strategy in 1991. This new

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[50] Analysis based on numbers from NE *Annual Reports and Accounts*, and analysed in MacKerron op. cit. p. 151-154.
[51] NAO *The cost of decommissioning nuclear facilities'*, May 1993, p. 2

'Deferred Safestore Strategy' was put forward for Government approval.[52] The stages were:

Stage 1 Removal of the final spent fuel from the reactor core

Stage 2 Dismantling the non-radioactive parts of the stations (outside the biological shield) and the construction of a "safe store" over the full plant, after approximately 30 years

Stage 3 Dismantling of the reactor core and clearance of the site, approximately a century later.

4.21 This would extend the delay in dismantling from about 100 to 135 years, and assumed that, once cocooned in the 'Safestore', the site could be left unmanned until the final stage. It did not appear to be critical whether the Safestore was constructed early or following a delay of 35 years, but cash flow considerations led to a strong preference for deferring (deferral was argued to be beneficial at discount rates above a relatively low rate of about 1.5%). Although the review suggested that this would be an attractive strategy, the alternative of in-situ decommissioning ('entombment') would be easily the cheapest if the safety case could be made and environmental and planning authorities satisfied, but it was never pursued. There was also later criticism that the option of early decommissioning was excluded.

4.22 The review resulted in reducing the estimates of the cost of decommissioning, even using the existing Reference Strategy, from £3.5 billion (discounted in 1991 prices) to £2.9 billion. The Deferred Safestore Strategy would further reduce the discounted liability to about £2.1 billion. The net effect on NE's profit and loss accounts would be an annual saving in provisions of around £90 million, £50 million of which was directly due to the strategy change. The current balance of (discounted) decommissioning provisions in the accounts could also be reduced by about £800 million to around £1.2 billion.

[52] F Passant, *Power station decommissioning – UK Strategy*, Nuclear Electric, (undated, probably 1993)

4.23 The NAO noted the uncertainties (eg surveillance costs might be higher) and risks of long delay to Stage 3, including the possibility of increased regulatory requirements in the dormant period.[53] But it also noted that when the AEA had reviewed CEGB's cost estimates, it found that if decommissioning was carried out 10 years after shutdown, average undiscounted costs would increase by about 50 per cent for Magnox reactors - though only by 5 per cent for AGRs.

4.24 The NAO concluded overall that, given there was no guarantee that the provisions would be sufficient for future liabilities, it was appropriate for Departments to try and ensure that the industry was improving its efficiency and facing up to the costs of decommissioning. They also advised that the Department should ensure that discount rates used were reasonable and realistic, having previously observed that DTI was effectively hands-off on choice of discount rate.

The Segregated Fund for British Energy Liabilities

4.25 British Energy inherited the AGR and PWR liabilities, valued officially at £14 billion (undiscounted) later reduced to £12.9 billion, and BE had legal responsibility for their discharge.[54] Following consultation as part of the nuclear review, the Government decided that a segregated fund, managed externally to the company would offer greater assurance than allowing BE to make its own provisioning arrangements. The choice of funding route was influenced by the flaws of the internal unsegregated approach, which could only work if the assets that the fund invests in are profitable - and these profits are in turn large enough and are available to the body responsible for discharging the liabilities. These conditions could not be met in the case of the utilities' earlier 'funds': the nuclear investments made over the life of the funds were unprofitable and other investments made by the utilities were lost to the liability discharge task because they went into non-nuclear companies.

4.26 The BE fund was to consist of relatively liquid assets, kept separate from the utility's other assets and held externally, by a trust. It had three

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[53] NAO op. cit. pp. 14-15
[54] British Energy *Annual Report and Accounts 1996/7*

sources of income: an initial endowment of £228 million from the taxpayer; an annual contribution from BE, declining as its stations close plus the proceeds from its investment portfolio, which consisted of equities, property and cash deposits. The fund was originally only designed to cover Stages 2 and 3 of decommissioning: Stage 1 was expected to be covered from operating income.[55]The Fund did not cover spent fuel and other waste liabilities. British Energy re-negotiated its spent fuel contracts with BNFL in the later 1990s and was contractually committed to paying for all future spent fuel management. While many of these commitments would be operating costs and paid for as fuel was delivered to BNFL, there remained a substantial level of future liability, especially for wastes, for which there was no provision. British Energy announced in its Prospectus that it would make future investments to cover these liabilities arising after all reactors were closed down.[56] As the Select Committee on Trade and Industry argued in 1997, this did not represent sufficient assurance that the company would meet all future liabilities.[57] (See Chapter 8, paras 8.17 – 8.20, for further developments and discussion.)

Quinquennial reviews of decommissioning strategy

4.27 The Government effectively accepted the change to the Deferred Safestore Strategy in the White Paper on radioactive waste management policy, one of the 1995 White Papers that came out of the nuclear review.[58] However, Government noted that decommissioning had to meet HSE's licence conditions and it specified that all nuclear operators should draw up decommissioning strategies which would be reviewed quinquennially by HSE. consulting the Environment Agencies, to ensure they remained sound. Government also stated its belief that, in general, the process of decommissioning nuclear plants should be undertaken as soon as it is reasonably practicable to do so.

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[55] See M. Sadnicki and G. MacKerron *Managing UK Nuclear Liabilities* STEEP Special Report no. 7, SPRU, Sussex, October 1997, p.p. 26-29 for a fuller analysis.
[56] *Prospectus, British Energy Share Offer,* 26 June 1996, p. 73
[57] Trade and Industry Committee, *Nuclear Privatisation,* 2nd Report, HC43-1, Session 1995-96, 14 /February 1996, para. 55
[58] *Review of Radioactive Waste Management Policy*, Cm 2919, 1995, paras 121-131

4.28 Following the first quinquennial review in 1996, Magnox Electric – which took over almost all of the Magnox fleet when British Energy was privatized – conducted a further review and modified its decommissioning strategy in two ways: only the dismantling of the reactor buildings was to be deferred for the whole period, and there would be a sequenced programme of reactor dismantling to spread resource and allow learning from experience. The trustees of the BE fund (then known as the Nuclear Generation Decommissioning Fund, later re-named the Nuclear Liabilities Fund) carried out a QQR in 2001 of the private sector funding arrangements and concluded that there was inadequate funding to meet all BE liabilities

4.29 In the second NII quinquennial review in 2002, existing strategies were found to be appropriate and the provisioning for dismantling after 85 years reasonable. But NII expressed a number of reservations including questioning why a shorter timescale was not reasonably practicable and highlighting the potential impact of regulatory tightening in future on this timescale. The NII pressed for further clarification of the underlying assumptions used, and noted that should ME be required to bring forward its stations' dismantling programme to significantly less than 70 years from end of generation, additional financing would be required unless predicted costs could be reduced proportionately. Despite these regulatory pressures to bring forward final dismantling (and independent commentators' views to the same effect)[59] the timetable for dismantling remained lengthy, and financial pressures – a desire to minimise the level of current provisioning - seem to have been the primary driver.[60]

Waste management and Nirex

4.30 The mid-1970s was also the time when serious thought first was given to the long-term management of radioactive wastes. In 1976 the Royal Commission on Environmental Pollution (RCEP) published the landmark 'Flowers report', which stressed the urgency of establishing a credible

[59] These date back to the 1990s. See for example G. MacKerron, J. Surrey and S. Thomas *UK Nuclear Decommissioning Policy: Time for Decision* , SPRU, Sussex, January 1994
[60] HSE, *UKAEA's strategy for the decommissioning of its nuclear licensed sites: A review by HM Nuclear Installations Inspectorate*, October 2002

management route for radioactive wastes classified as being at intermediate and high levels.[61] The original plans for dealing with operational and decommissioning wastes from the power stations were based on sea disposal - and some waste was disposed to sea. The political decision to end sea disposal after 1982 had a significant impact on costs. A new industry-owned body, Nirex, was set up. After the 1982 postponement of any attempt to look for disposal routes for high-level (heat generating) waste for 50 years, it focused on seeking underground disposal sites for low and intermediate level wastes. Its early attempts met with stiff resistance from local communities, and sites were consequently abandoned. In the mid-1990s it made what turned out to be a final attempt to get planning approval for a rock characterization facility near Sellafield to implement a programme of underground investigations to determine whether the site was suitable for hosting a repository. This application was refused in 1997 after a major planning inquiry and appeal to the Secretary of State. This signalled the end of the so-called 'Decide-Announce-Defend' approach to radioactive waste policy-making and a new approach was taken in the early 2000s, as Chapter 7 describes.

4.31 In the course of its existence from 1982 until March 2007, Nirex spent over £600 million on the waste disposal programme. A large proportion of this spend was related to undertaking surface based investigations at the Sellafield site (i.e. drilling boreholes and interpreting the information that was gained). The techniques and methodologies developed in the Nirex programme have been further developed internationally. If the current UK site selection process progresses it will benefit from some of the developments that have taken place internationally since 1997, which in some cases build on early Nirex work. The value of the site-specific work will depend on which communities take a decision to participate and which areas are investigated further.

[61] Royal Commission on Environmental Pollution *Nuclear Power and the Environment* 6th report, Cm 6618, September 1976

CHAPTER 5 – REPROCESSING AND SPENT FUEL MANAGEMENT

- Spent fuel has been treated in the UK as a potential resource (through the separation through reprocessing of uranium and plutonium) rather than waste.
- The UK's civil stockpile of separated plutonium is currently treated as a 'zero-valued asset' in line with existing Government policy (indefinite storage) pending an ongoing policy review The evidence is that plutonium is a liability, because reprocessing is costly, plutonium has no commercial value and the costs of managing reprocessing products are high.
- The costs of transforming plutonium into fuel, using it in reactors, and then managing the resulting spent Mixed Oxide(MOX) fuel, are higher than the cost of uranium–only fuel. The extent of this excess cost – should the existing stockpile of plutonium be used in MOX – is not yet clear. Dealing with the plutonium stockpile is now primarily a security/non-proliferation issue and all feasible management routes will lead to net costs, not benefits.
- For Magnox, the military imperative and the almost universal belief in fast breeders, means reprocessing was originally the only feasible path. More recently, the failure to establish robust long-term storage technology for Magnox fuel has meant that reprocessing has necessarily continued.
- The position is different for the AGRs. The excess economic cost of reprocessing spent AGR fuel was clear long before THORP was completed. And in 1994, Scottish Nuclear (SN) expected to halve the cost of spent fuel management by building a dry store instead of reprocessing.
- Spent fuel reprocessing was funded in the Magnox case mostly out of current revenue by the relevant utilities (i.e. by consumers), but funding was not set aside to address the clean-up of the Magnox reprocessing facility and reprocessing wastes. All are now the responsibility of the NDA.
- For AGRs, almost all spent fuel management costs have been treated as future liabilities, though the utilities have already paid for some of the costs of reprocessing via their contractual arrangements with Sellafield
- The waste management argument in favour of reprocessing is threadbare, because any (limited) savings in high level waste management costs and uranium use are overwhelmed by the extra costs of reprocessing itself and the need to manage greater volumes of other wastes produced by reprocessing.
- The value for money of the UK's commitment to reprocessing spent fuel has been poor. The costs of spent fuel management would have been much lower had spent fuel been stored rather than reprocessed. The economics of any new reprocessing plant would be exceptionally poor, in view of the costs involved and the lack of any significant market for plutonium-based fuel.

Introduction

5.1 UK policy towards the nuclear fuel cycle was based, until recent years, on a conviction that reprocessing was essential - meaning that plutonium and unfissioned uranium should be extracted from spent fuel. This was expected to be vastly superior to the apparently wasteful notion of storing the spent fuel, treating it as a waste product and disposing of it directly. However, the most important conclusion of this chapter is that in the management of future spent fuel, a commitment to long-term spent fuel storage will provide much better value for money than reprocessing - as it would have done for many years in the past.

The case for reprocessing Magnox spent fuel

5.2 There are two main origins of the idea that reprocessing was worthwhile. The first was that early UK efforts in nuclear technology were devoted to securing an effective and rapid route to indigenous production of nuclear weapons. The UK chose a route to nuclear weaponry through the production of plutonium because this was seen as the most ‘efficient’ route. The chosen technology, Magnox, worked by irradiating uranium ‘fuel’ to produce large amounts of plutonium which could then be separated via reprocessing and used for bomb-making. When attention began to be given, in the early 1950s, to the potential of nuclear fission for power production, stimulated in part by shortages of domestic coal, the logical choice was to use the heat generated in the nuclear reaction in Magnox designs to drive a turbine generator. Thus Calder Hall, commissioned in 1956, was primarily a plutonium producer for weapons use, but also had a significant electrical output. Chapelcross was similarly a weapons-based facility that also produced power. For Calder Hall and Chapelcross to function as military facilities, there needed to be a reprocessing plant available to separate the plutonium from the spent fuel. Thus reprocessing was an integral part of early Magnox development.[62]

[62] See Chapter 2.

Box 5.1 - Reprocessing vs. spent fuel management

When spent fuel is taken out of nuclear reactors, it is stored under water for a period of around a year to allow it to cool. There are then two alternatives: continued storage, either with or without a decision to treat the fuel as waste; or the 'reprocessing' of the fuel in order to recover plutonium and unfissioned uranium.

Storage Worldwide, most spent fuel is stored rather than reprocessed and several countries have taken the decision that the stored fuel will be treated as a waste. After the period of cooling under water, the spent fuel will then often enter a period of dry storage, after which it can be encapsulated ready for final disposal. Both wet and dry storage involve simple, relatively inexpensive and well-developed technology. Spent fuel encapsulation is also relatively straightforward. Encapsulated fuel is treated as high level waste. This is known as the 'open fuel cycle'.

Reprocessing Commercial scale facilities for reprocessing exist currently in the UK, France and (more recently) Japan. In these facilities – large mechanical/chemical engineering industrial plants - the spent fuel is chopped into pieces and then dissolved in boiling nitric acid, involving substantial radiological shielding and limited human access. The products are plutonium, unfissioned uranium and a variety of waste products. Besides Highly Active Liquors (HAL) which are then subject to evaporation and then vitrification (making into glass blocks) as stable high level waste forms, further waste streams are created during the reprocessing operation itself, some classified as low level and others at intermediate level. The technologies involved here are also well-developed. Overall, reprocessing is part of the 'closed fuel cycle' where recovered plutonium and uranium can be re-used in reactors.

Reprocessing is inherently much more complex and expensive than storage. From an economic perspective, it is therefore only worth considering if the value of its main products – reprocessed uranium and plutonium – are large enough to overcome the large cost penalty of the reprocessing operation itself. In practice reprocessed uranium and plutonium have had at best zero value (there has been no commercially-derived demand for them) and plutonium storage incurs significant costs, especially for security reasons. As the Royal Society recently reported 'all [studies across the world] conclude that the open fuel cycle currently has cost advantages over the closed fuel cycle'.[63]

5.3 As the need for military plutonium reduced and more and larger Magnox stations were commissioned, a second justification for reprocessing became prominent.[64] This was the idea that plutonium would become an essential fuel input for civilian nuclear power. Uranium was thought to be

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[63] Royal Society *Fuel cycle stewardship in a nuclear renaissance* October 2011, p.16

[64] See F. Berkhout and W. Walker *THORP and the Economics of Reprocessing* SPRU, Sussex, November 1990, pp. 3-5 for more detail on these rationales

inherently scarce and as world demand for uranium grew, it would inevitably therefore become very expensive. As thermal reactors of the Magnox and similar types could only convert around 1% of the uranium in the fuel to useful power, and the FBR might in principle extract up to 50 or 60 times more energy from a given quantity of initial uranium than a thermal reactor, it was regarded as inevitable that FBRs would, within a quite short timespan, become the dominant reactor type. But breeder reactors needed a large starting inventory of plutonium and so it seemed axiomatic that reprocessing was a crucial step towards fulfilling the long-term vision of a nuclear power future. The fast breeder was in principle able to 'breed' more fuel than it originally contained. This would be achieved by placing a blanket of U-238 round the core of the reactor, which in turn would capture a neutron to make large further quantities of Pu-239. In this highly attractive vision, once there were sufficient start-up quantities of Pu-239 (for fuel) and U-238 (for the blanket) the fast breeder would produce ever-expanding quantities of future fuel, and thus liberate power systems from further dependence on natural resources.

5.4 When it became clear in the 1950s that early Magnox reactors were unable to compete with coal-fired power in financial terms, the gap was more than filled by the notion of a 'plutonium credit' – the imputed value of the separated plutonium as a future fuel input to FBRs.[65] When doubts began to emerge about the size or even legitimacy of this plutonium credit, leading in turn to doubts about the economic value of Magnox generation overall, a further argument in favour of continued reprocessing was used. This was that when Magnox spent fuel was wet-stored (the universal early practice until the last Magnox was built at Wylfa) it would corrode dangerously if left too long under water, and the only remedy was to extract the fuel and reprocess it. This meant that after all the Magnoxes were built, reprocessing continued, even though it was expensive and even if – as became increasingly apparent during the 1980s[66] – there was no easily foreseeable possibility of re-using

[65] Hall, *Nuclear Politics*, p.53.
[66] As early as 1980, independent work on uranium suggested that the large reserves of world uranium meant that fast breeders were not necessary and might prove very expensive. See

the plutonium in FBR.[67] Thus, spent Magnox fuel is reprocessed to this day in the old and often-refurbished Magnox reprocessing facility at Sellafield.

5.5 What the nuclear industry was however unwilling to recognize until too late was that it had always been possible in principle to dry-store Magnox spent fuel, thus avoiding the corrosion problem and apparent need to reprocess. In fact, spent Magnox fuel at Wylfa is dry-stored for limited periods, though primarily as a buffer against the risk that Sellafield cannot handle the full volumes of fuel discharged from reactors. Further technical development would have been needed to guarantee the safety of long-term dry storage. NDA is in fact currently investigating potentially robust routes to Magnox fuel storage, but current expectations are that all Magnox fuel will be reprocessed.

Reprocessing AGR spent fuel

5.6 When the second generation of UK reactors was approved in 1965, the conviction that reprocessing was a critical part of the overall nuclear project was still strong. It was therefore expected that spent AGR fuel would be reprocessed, though delays in the AGR programme meant that no spent fuel from AGRs was available until the late 1970s. Meanwhile events in the early 1970s, most notably the first oil crisis of 1973/4, gave impetus to the FBR/plutonium vision. Several European countries including the UK launched ambitious plans for nuclear expansion. Partly as a consequence of these new plans for nuclear power but also partly because exporting spent fuel to other countries was politically attractive, there was an emerging international demand for reprocessing services, with several countries - most notably Japan, but also Germany, Switzerland and Sweden - showing interest in having spent fuel reprocessed, initially in France but also potentially in the UK.

5.7 Initially BNFL hoped that the original Magnox reprocessing facility could be modified to take the enriched uranium oxide fuel that both AGRs and overseas PWR/BWR reactors would use. When such modification was

C. Buckley, G. MacKerron and J. Surrey 'The international uranium market', *Energy Policy* June 1980, pp. 84-104.

[67] R&D work on fast breeders at Dounreay began to be run down from 1990 and ceased completely by 1994.

attempted to the head end part of the plant in 1973 it was unsuccessful and BNFL decided that a new oxide fuel reprocessing plant was needed. This proposed plant, THORP, was subject to public inquiry (the 'Windscale inquiry') in 1977 and approval for construction was given after a favourable Inspector's report which emphasised the importance of export business especially from Japan.[68] The dominant expectation remained that the plutonium separated in reprocessing would eventually be used for FBRs, though it was recognised that plutonium could be used in mixed oxide (MOX) fuel for conventional reactors.

5.8 In 1989 money, the cost of constructing THORP, its ancillary plant and decommissioning was £2.9 billion,[69] in addition to which it had very significant operating costs, employing over 2000 people and producing a variety of new waste streams in addition to high level waste, uranium and plutonium. However, the commercial terms under which THORP was built were highly favourable to the UK. Overseas customers, especially Japanese utilities, paid for a large proportion of the construction costs and were in principle liable to pay on a cost-plus basis for operations. Nevertheless, there was international evidence that for oxide fuel storage was cheaper than reprocessing.[70] Indeed some 75% of all the world's spent fuel was destined for long-term storage rather than reprocessing, including all US fuel after the Carter administration banned reprocessing in 1977. There now is no serious doubt that the interim storage of spent fuel would have been substantially less expensive than reprocessing for the UK utilities. The question that arises is why the utilities chose to sign up to reprocessing contracts. There are three main probable explanations:

- The reprocessing prices charged to CEGB and SSEB were lower than for overseas spent fuel, meaning that the cost penalty for reprocessing was smaller than if full costs had been charged;

[68] *The Windscale Inquiry* Report by the Hon. Mr. Justice Parker, HMSO, 1978
[69] BNFL *The Economic and Commercial justification for THORP* Risley, July 1993, p. 18.
[70] A good example is the report from the Nuclear Energy Agency in 1985 (OECD/NEA *The Economics of the Nuclear Fuel Cycle*, Paris), which showed that even on assumptions favourable to reprocessing (for example allowing the idea of a monetary credit for the value of separated uranium and plutonium) the reprocessing cycle was significantly more expensive than a storage cycle (pp. 75-76)

- As cost-plus monopolists, the utilities passed on all incurred costs to consumers, and so had limited incentives to minimize costs;

- Despite these mitigations, the CEGB and SSEB were still resistant to the pressure to continue reprocessing in the 1980s. They developed a joint plan to construct a dry store for AGR fuel, which would have enabled them to avoid reprocessing contracts, but this came to nothing, and in 1986 they signed new contracts with BNFL.[71] It was therefore not clear that the utilities had the power to act independently and refuse reprocessing contracts. As nationalised industries they were subject to direct political pressure (the argument was heard at the time that selling reprocessing services to overseas customers would be harder if home customers were not signing up). And it was certainly the case that AGRs were built - unlike the later Sizewell B PWR - without significant on-site spent fuel storage capacity. This meant that spent fuel had to be shipped to Sellafield, and BNFL were not at that time offering storage contracts, only reprocessing services.

5.9 One additional argument sometimes used in the attempt to justify reprocessing - in the absence of any foreseeable military or market demand for plutonium - is that it makes the overall process of waste management easier and cheaper. Reprocessing produces, by volume, around 3% of high level waste products, plus about 1% plutonium and 96% uranium. The volume of HLW is therefore much smaller under a reprocessing regime than under direct spent fuel disposal, where all the fuel is treated as HLW. However this argument does not translate into a need for much lower volumes of waste to be disposed in a repository if reprocessing is chosen, or much smaller repository space needed. This is because:

- The space needed in a repository for HLW is not directly proportional to its volume but also related to its heat-generating characteristics. This means that the saving in space for HLW in a repository under reprocessing scenarios is smaller than the difference in volumes compared to spent fuel disposal suggests;

71 F. Berkhout *Radioactive Waste – Politics and Technology* Routledge 1991, p. 180.

- Reprocessing substantially increases the overall volume of wastes to be managed, as new liquid waste streams (many classified as Intermediate Level Waste) are produced during reprocessing and also need to be disposed in a geological repository;

- Over a longer time frame, the MOX fuel that is produced from plutonium after reprocessing is not, in current or immediately foreseeable conditions, expected to be reprocessed. This is because the economics of reprocessing MOX are even worse than of uranium-only fuel and so it is expected that MOX will be disposed directly. MOX fuel is hotter and more difficult to handle than uranium-only fuel and the consequence is that it will probably cost more to dispose in a repository. Any advantage that reprocessing might offer for waste management is therefore nullified over the medium term when spent MOX fuel has to be disposed directly.

For these reasons, there is no clear advantage to reprocessing as a means of minimizing waste management costs, and in any case there is the high cost of reprocessing relative to spent fuel encapsulation to set against any marginal waste management argument in favour of reprocessing.

5.10 Strong further evidence that storage would have been a cheaper option despite the relatively lower prices offered for reprocessing to the home utilities came from Scottish Nuclear in the early 1990s. It revived the idea of a dry store originally considered in the mid-1980s, arguing that they could save £45 million annually by moving to storage rather than reprocessing for AGR fuel.[72] This would cut spent fuel management costs in half. A detailed design was worked up and a public inquiry ending in 1993 concluded that the proposed dry storage represented ' a sound engineering solution' [73]. Again, however, SN eventually signed new reprocessing contracts with BNFL and the storage idea was abandoned.

[72] Scottish Nuclear, *Securing our Energy Future*, Submission to the Government's Review of Nuclear power, July 1994, para. 51 p. 14
[73] Scottish Nuclear, op. cit. para. 52, p. 14

5.11 By the time that the AGRs were privatized in 1996, the electricity market had also been liberalized, so that British Energy had cost-saving imperatives and relative political freedom to choose what to do with spent fuel. In addition the UK fast reactor programme had been abandoned in the early 1990s and there was no longer any foreseeable prospect of using plutonium in fast reactors. Reprocessing had therefore become an expensive operation to produce a primary output for which there was no prospect of any demand. It was true that the plutonium was potentially useable in mixed oxide fuel (MOX) for conventional reactors, but this was a more expensive way to fuel reactors than uranium-only fuel. Nevertheless foreign customers of THORP in some cases wished to receive their plutonium back in the form of MOX, and so BNFL built the markedly unsuccessful Sellafield MOX Plant, the closure of which was announced in August 2011, to try to meet this overseas demand

5.12 On acquiring the AGRs in 1996, British Energy became increasingly vocal in declaring that it wanted to re-negotiate lower prices for the fuel that already been contracted for reprocessing, and in addition did not sign reprocessing contracts for that part of future spent AGR fuel which was at the time still uncontracted. Instead it signed ‘management’ contracts for BNFL to manage this residual AGR fuel, without commitment to reprocess, at substantially lower prices.[74] Questioned by Select Committees about the economic and financial viability about reprocessing in 2001,[75] BE declared unequivocally that reprocessing was a highly expensive and unwanted option relative to interim storage and that ‘our contracts, which currently provide for ongoing reprocessing, should …cease and be converted into storage contracts’.[76]

5.13 The evidence internationally about the relative costs of reprocessing and interim storage overwhelmingly point to interim storage as the substantially cheaper option. This is true even in France – the country that has led the way in reprocessing and achieved admirably good performance in

[74] British Energy *Annual Report and Accounts 1997/98,* p. 4
[75] Following its *Memorandum submitted by British Energy* Select Committee on Environment Food and Rural Affairs, November 2001
[76] House of Commons Environment Food and Rural Affairs Committee, *Minutes of Evidence*, 26 November 2001

the technology - where a sophisticated and authoritative study sponsored by the then Prime Minister in 2000[77] showed convincingly that fuel cycle costs would have only around half as high if reprocessing had never taken place, and that it would be profitable to stop reprocessing at the earliest feasible moment. This analysis therefore showed that in French conditions, it would be cheaper to stop reprocessing even after counting all the costs of building reprocessing facilities as sunk.

Conclusion

5.14 It is clear that while reprocessing was inevitable in the early years of the UK nuclear programme, it became a genuine choice after the AGR programme was adopted in 1965. Commitment to reprocessing spent fuel however remained firm until the 1990s (with contractual commitments stretching well into the present century). The consequence is that the process of managing liabilities has been much more complex and expensive than if decisions has been taken after the late 1970s, in keeping with those made in most other nuclear-using countries like the USA - to abandon reprocessing in favour of spent fuel storage.

5.15 There are important questions about the economics of refurbishing THORP with a view to running it to 2040 rather than, as currently planned, closing it when existing contracts are completed. A recent analysis[78] suggests that refurbishment of THORP might make sense in economic terms, but only if there was a 'strategic rationale for overseas and/or UK new-build utilities to contract for reprocessing services'.[79] It is difficult to see what this 'strategic rationale' might be and in its absence the same report concludes that there is no case for extending THORP's lifetime. This seems an entirely sensible view, as future international demand for MOX fuel, if separated plutonium does not already exist, is at best minimal. The NDA has recently announced that THORP its intention to close THORP when current contracts

[77] Charpin, J-M *Economic Forecast Study of the Nuclear Power Option* (translated from the French original) Report to the Prime Minister, 2000.
[78] Smith School of Enterprise and the Environment *A Low-Carbon Nuclear Future: Economic assessment of nuclear materials and spent nuclear fuels management in the UK,* University of Oxford, March 2011
[79] Smith School, op. cit. p. 7.

are fulfilled around 2018.[80] There can be no doubt that, in the absence of any military or significant market demand for separated plutonium, there is no conceivable economic case for building a *new* reprocessing plant in the UK.

[80] NDA *Oxide Fuels: credible options,* November 2011

CHAPTER 6 – WHERE DID THE MONEY GO?

- Funds collected from consumers for back end liabilities between 1976 and 1988 were 'lost' to the nuclear industry at the time of electricity privatisation because the assets in which the funds were invested either went to non-nuclear companies or were unprofitable.

- The Fossil Fuel Levy (1990-1996) raised over £6 billion for Nuclear Electric and this helped BE to generate surplus cash of £2.6 billion which was earmarked for liability discharge by a transfer to Magnox Electric and thereafter to BNFL's Nuclear Liabilities Investment Portfolio (NLIP).

- BNFL spent relatively little on decommissioning and waste management between 1996 and 2005, and after BNFL was wound up (at which point the Government committed to funding the clean up programme from public funds), the NLIP, valued at over £4 billion, primarily went into the Consolidated Fund.

- From 2004 – 2010, BNFL returned £8.2 billion to taxpayers in dividends and transfers (adjusted £9 billion). This included principally the receipts from the sale of Westinghouse (£3 billion), the NLIP (£4.3 billion), and Springfields (£151 million).In 2008 BNFL transferred its share in URENCO to the Government, which is currently estimated at £2-3 billion**.**

- Since 2005 Government has provided grants of £9 billion to the NDA to carry out decommissioning activity (to 2010-11). This will rise to £17.6 billion by the end of the current Spending Review settlement in 2014-15.

- Government contributed £228 million to the initial Nuclear Decommissioning Fund which British Energy was required to set up to meet the costs of decommissioning its AGRs and PWR. In the early 2000s, British Energy got into financial difficulties. Government put together a restructuring package valued at a cost of around £3 billion to the taxpayer. As part of the rescue package, the Government accepted responsibility for underwriting the Nuclear Liabilities Fund (NLF) should its funds prove insufficient in meeting all liabilities.

- In 2009 EDF purchased the restructured company for £12.5 billion. The Nuclear Liabilities Fund (NLF) received £4.4 billion at the time for its 36% stake. The NLF's assets are currently worth around £8.6 billion.

- It is important that the NLF will be capable of fully meeting all outstanding liabilities for the AGR / PWR fleet. Achieving this outcome is dependent on a number of variables, including the level of base UK interest rates (which dictate the returns available for the bulk of the fund), the eventual lifetimes of the fleet, and the effectiveness of plans for decommissioning and their execution.

6.1 The 1976 'Flowers report'[81] was a catalyst for the nuclear industry to think about back end liability problems for the first time. In the case of the utilities (CEGB and SSEB) the practical task of decommissioning their own reactors would not take place until some years in the future and it was not necessarily evident that reprocessing of spent fuel should constitute a long-term liability rather than an operating cost of spent fuel management. In addition, the utilities were probably unaware that they would be expected to pay for their share of the costs of decommissioning BNFL facilities – mainly Magnox fuel manufacture at Springfields and Magnox reprocessing at Sellafield - which were built for their exclusive use. And neither utility had ever conducted any serious study of decommissioning costs.

6.2 However in 1976 both utilities started to collect payments for back end liabilities from customers, where liabilities were first defined in terms of decommissioning their own nuclear stations plus reprocessing costs, but from 1981/2 both utilities included their share of decommissioning BNFL facilities[82] (see Chapter 4). These moneys were 'held' in an 'internal unsegregated' fund, meaning that while the accounts showed an accumulating sum, the money entered into the general cash flows of the utilities and represented cheap finance. It was therefore not possible to access these funds for liabilities management because they were used to fund general investment. By 1988 these 'funds' had reached over £3 billion but on privatisation of the non-nuclear parts of the electricity supply industry in 1989-90, the bulk of the assets in which the 'funds' had been invested did not go to Nuclear Electric (NE) or Scottish Nuclear.[83] This was because most CEGB/SSEB investment during the period of the decommissioning funds' existence went into non-nuclear assets that went to other companies at privatisation, and where limited nuclear investments took place (mainly into the completion of AGRs)

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[81] Royal Commission on Environmental Pollution, op. cit.
[82] National Audit Office *The cost of decommissioning nuclear facilities* Report by the Comptroller and Auditor General, HMSO, London, June1993, Appendix D, p. 34.
[83] Because of the hasty and unusual accounting arrangements that were made in 1988/89 in an ultimately vain attempt to privatise nuclear power, the 'provisions' (ostensibly 'funds') shot up in 1989 to over £8 bn. However this very rapid rise did not reflect extra revenue raised from consumers.

these proved uneconomic investments and hence were unable to generate surpluses that might have been used to pay for liabilities.

6.3 The period from 1976 to 1988 was therefore the first time that consumers were apparently paying for decommissioning and waste management, but the ‘funds’ so collected were not used for their intended purpose. The Consolidated Fund benefited through the increased value it recouped from utility privatisation. However, the apparent priority that had been given to funding decommissioning had been at best severely diluted (though Governments of the day would have felt the need to balance this against other priorities). As Chapter 4 also spells out (4.13 - 4.17), Nuclear Electric benefitted from 1990 to 1996 from the proceeds of another consumer charge, the Fossil Fuel Levy, some 97% of which went to the company, a total of over £6 billion. The money was primarily designed to ensure that Nuclear Electric was ‘cash-positive’ and could trade legally. It was not intended to pay primarily for liabilities.

6.4 Because NE was able greatly to improve the operating performance of the AGRs and hence its income, the £6 billion of Levy proceeds, added to its operating income, turned out to be more than it needed. As the proceeds of the FFL went into a general company revenue stream, it is impossible to attribute specific expenditures to the Levy, though as paragraph 4.17 explains, some 50% of the value of the Levy was spent on reprocessing spent fuel.

6.5 By 1996, Nuclear Electric had a £2.6 billion cash surplus and this was transferred to the new Magnox-only company, Magnox Electric (ME), which in 1997 became a wholly-owned subsidiary of BNFL. The donation of £2.6 billion to Magnox Electric was designed to help ensure its ability to trade legally, given that it had very large liabilities (£18.5 billion undiscounted, or £8.9 billion discounted)[84] by 1996. Government attempted to show in 1995 that there would be ways that ME could meet its liabilities, suggesting that £2.4 billion would be available from future net income and further FFL proceeds, £2.0 billion would come from cash in the company balance sheet,

[84] Magnox Electric *Directors’ Report and Accounts* year ended March 1997, p. 8.

£1.4 billion from back end savings, including implementing the Safestore decommissioning strategy (see 4.17-4.22) and £2.6 billion from the sale proceeds from BE.[85]

6.6 These Government expectations proved to be substantially optimistic, and even the £2.6 billion in cash was insufficient for ME's balance sheet to avoid showing an excess of liabilities over assets. Government also therefore had to give the 'Magnox Undertaking' – a commitment that it would help meet ME liabilities as they fell due if the company was unable to find the cash itself. This Magnox Undertaking was valued at £3.8 billion, starting in 2008 and in principle extending to 2116, and carrying a real interest rate of 4.5% per annum.[86] This however was a means to ensure that ME could trade legally, and it was extinguished as BNFL was broken up in the later 2000s. However the £2.6 billion was a real cash sum and was intended explicitly to help pay for liabilities.

6.7 UKAEA was responsible for the decommissioning and waste management costs of facilities on its own R&D sites, primarily Harwell, Winfrith, Dounreay, Culham and parts of Sellafield. However there was never any attempt to set up a long-term fund of any kind for the UKAEA: instead Government funded actual liability management expenditures on an annual basis. In the 1990s, following the cessation of almost all UKAEA R&D work, the UKAEA conducted significant amounts of decommissioning activity, which was directly funded by taxpayers at an average annual rate of just over £100 million annually in the mid 1990s.[87]

6.8 The £2.6 billion surplus FFL proceeds, following the transfer of ownership of ME to BNFL in 1997, became part of - indeed the major contributor to – a Nuclear Liabilities Investment Portfolio, which BNFL set up to meet long-term liabilities. The NLIP was a real 'fund' managed externally to the company and placed in a mixture of equities and gilts. It was however not

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[85] DTI 'Magnox Liabilities' Annex to Press notice *The Prospects for Nuclear Power in the UK* P/95/310, May 1995

[86] T. Eggar, *Hansard*, 10 May 1996, col. 296.

[87] D. Pooley 'A radical approach to decommissioning and nuclear liabilities management' *Nuclear Energy,* 35:2, April 1996, p. 125.

a segregated fund or run by an independent trust: it was internal to the company and therefore not guaranteed to be available for its stated purpose. Together with other ME cash and some of BNFL's own cash surpluses the NLIP reached a value of over £4 billion by 2002 . While this was a substantial sum, it is also worth noting that in the same year, BNFL's total liabilities, undiscounted, amounted to some £40.5 billion with a discounted value of over £21 billion[88] (and these numbers would continue to rise subsequently).

6.9 The Government consulted on funding options in the 2002 White Paper '*Managing the Nuclear Legacy*'. This set out its strategy to establish a new Liabilities Management Authority to own and be responsible for clean-up of all BNFL and UKAEA sites (see Chapter 7).The White Paper invited views on two innovative approaches being considered: a fully segregated fund for liabilities or – the preferred option - a Treasury-held segregated account.[89] This was not subsequently implemented (see Chapter 7), but if it had been, there would have been one further opportunity to find a convenient endowment for such a funding system. This would have been to devote some or all of the proceeds of selling the various parts of BNFL to the NDA. Between 2004 and 2010, BNFL returned over £10 billion to the Consolidated Fund at today's prices – principally from the sale of Westinghouse *(£2*.9 billion), and the NLIP (£4.3 billion)). These funds were instead earmarked for general public expenditure, and were no longer available to fund decommissioning activity. In 2007 the UK's one third shareholding in URENCO was transferred from BNFL to Government. It is currently valued at between £2 billion and £3 billion.

British Energy liabilities

6.10 A different approach has been adopted to managing private sector liabilities. The political commitment at BE privatisation in 1996 (incorporating all the AGRs plus the Sizewell B PWR) was that 'liabilities would follow assets' into the private sector.[90] In pursuit of this goal, BE was required to set

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[88] THE NLIP and the liability figures are from DTI *Managing the Nuclear Legacy* Cm 5552. July 2002, Chapter 2.
[89] DTI *Managing the Nuclear Legacy*, chapter 6.
[90] *Prospects for Nuclear power in the UK: Conclusions of the Government's Nuclear Review,* Cm 2860, May 1995, especially para. 7.29

up a segregated external fund for liabilities, managed by an independent trust, so that money from the fund could not be used by the company for any other purpose than discharging liabilities. The fund was also independent of Government and though it entered into an agreed investment policy with Government. Government contributed £228 million to kick-start this segregated fund and the company had to make an annual contribution of £16 million into the fund.[91] The fund was called the Nuclear Decommissioning Fund (NDF) at the time because in practice the NDF was only required to fund Stages 2 and 3 of decommissioning.[92] Other long-term liabilities including all spent fuel management costs and Stage 1 decommissioning costs (£5.3 billion out of the undiscounted £12.9 billion value of undiscounted BE liabilities) were excluded from the Fund,[93] on the assumptions that earlier costs would be met from operating income and later costs would be met from further BE investments that would yield income after reactor closedowns. In the event, BE got into severe financial difficulties in 2001 and had to be financially rescued by Government.

6.11 Government restructured BE in 2004 at an estimated cost of c.£3 billion to the taxpayer at the time[94], in an arrangement whereby existing shareholders retained only 2% of the equity, with the remainder taken by creditors and Government. Under the terms of the agreement put in place as part of the restructuring/rescue package, BE was committed to paying in to the re-constituted segregated fund for liabilities, now known as the Nuclear Liabilities Fund (NLF) whenever it put fuel into its reactors in addition to the pre-specified cash payments from BE. The NLF also had entitlement to carry out a 'cash sweep' of 65% of BE's annual free cash flow and place it in the Fund[95]. As part of the restructuring, Government agreed to underwrite the NLF – so should its funds prove insufficient, the remaining decommissioning costs would be met out of the Consolidated Fund.

[91] Nuclear Liabilities Fund 'Purpose and history' www.nlf.uk.html, retrieved 8 January 2012.
[92] Watson Wyatt Investment Consulting *Nuclear Decommissioning Fund Limited* Report to DTI, June 1996, Appendix A.
[93] British Energy *Annual report and Accounts 1996/7,* and Watson Wyatt, op, cit. Appendix A
[94] NAO *The Restructuring of British Energy* (see appendix 2)
[95] The NLF, under direction by Government, could exercise its right to convert the BE payments to convertible ordinary shares in British Energy leading to a maximum 65% stake in the Company.

6.12 In 2008 British Energy was sold to EDF for £12.5 billion, and the NLF received £4.4bn for its 36% interest in the company at the time. This sum, together with £2.34 billion raised from the sale in May 2007 of some 28% of the Fund's interest in BE, has been invested by the NLF to fund the long term decommissioning costs of BE's existing stations, plus certain other contracted and uncontracted nuclear liabilities of BE as they arise. The NLF assets are currently around £8.6 billion.[96]

6.13 While the NLF has a degree of independence as a segregated fund under the legal framework as a Scottish public trust, it is classified as a public body, and Government has ultimate control of its investment policy. One of the central challenges of managing the fund for both the NLF and the Government is to decide between the competing drivers of either maximising returns (increasing the chances that the fund will cover the liability in full and there will be no extra cost to the taxpayer) or retaining the funds in the public sector to help support current finances and reduce the national debt (and accepting lower returns).

6.14 Government policy is use the NLF to reduce borrowing. The fund is reviewed every five years – the next one due in 2015 - to assess its prospect of fully funding the AGR and PWR liabilities under a range of scenarios. The current estimate of BE liabilities, discounted at 3%, is around £4 billion – or approximately £12bn undiscounted. Under some of those scenarios taxpayers might have to pay for some BE liabilities after mid-century, especially if returns on the fund remain at very low real levels. The NLF is discussed in more detail in Chapters 8 and 9.

6.15 The main distinction in practice between the method for funding the British Energy liabilities, and that used for those currently under the auspices of the NDA therefore lies not in the ability of the trustees to manage the fund, but rather in their ability to sanction expenditure from the fund without going through the Spending Review Process. This enables contracts to be let on a multi-year basis through the NLF without requiring annual Treasury approvals.

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[96] NLF *Annual Rpeorts*

The NDA however has a central role in scrutinising proposals from EDF for expenditure from the fund

6.16 One difficulty in the new arrangements for managing BE liabilities is that as Government has agreed to underwrite the fund and any liability expenditures for the foreseeable future will come from the NLF, there is no financial incentive for EDF to seek to minimise the liabilities. There is arguably a reputational incentive for them to do so (which could have financial consequences), and the NLF and NDA have received cooperation from the company in seeking to reduce costs – for example by exploiting synergies with the Magnox decommissioning programme. In addition, the NLF and NDA are considering, with EDF, how incentives to EDF can be improved.

Government payments for decommissioning

6.17 The converse of the transfer of funds from BNFL and the nuclear industry to the Consolidated Fund is that Government has assumed responsibility for the cost of public sector decommissioning. In the short run, decommissioning is also supported by revenues from the NDA's commercial activities.

6.18 Since 2005-06, Government has provided direct funding to the NDA of £9.01 billion, and under the terms of the 2010 spending review settlement this will rise to £17.65 billion by the end of the current SR settlement in 2015**.** The current assessment is that the UK's total liability for decommissioning the NDA sites amounts to £49.2 billion, discounted at 2.2%.[97]

Conclusions

6.19 There was a series of attempts from the 1970s onwards to set aside funds for tackling future nuclear liabilities. Those funds, which were initially collected from consumers, were not put in a segregated account, but rather invested in other assets which were either lost to the owners of nuclear liabilities, or ultimately returned to the Consolidated Fund.

[97] NDA *Annual Report and Accounts 2010/11* p. 23

6.20 It is not the purpose of this report to produce a full account of the net return or cost of the British nuclear industry to the public accounts over its history – and the transfers set out here are neither exclusive nor all directly comparable. However, in my view it is evident that from the 1980s onward, Government received significant receipts from nuclear power, without making an explicit provision for meeting nuclear liabilities, instead leaving the onus on future tax payers to meet the obligation. This is a lesson which seems to have been learnt – both in the establishment of the NFL, and in current plans for new nuclear.

6.21 In managing the NLF, Government has prioritised debt reduction over a guarantee that future liabilities will be met. There are arguments in favour and against this approach – which are discussed in detail in Chapter 8.

CHAPTER 7: THE DEVELOPMENT OF NEW INSTITUTIONAL AND FUNDING STRUCTURES AFTER 2000 IN THE PUBLIC SECTOR

- BNFL remained focused in the 1990s and early 2000s on commercial activity and getting the company fit for privatisation, not on cleaning up Sellafield. Pressure to deal with its liabilities came from the drive to privatisation: review in 1999-2000 showed they were a major barrier.
- Institutional changes. Following a review of the UKAEA, a new approach to liabilities management was detailed in the White Paper *Managing the Nuclear Legacy* in July 2002: a single new Liabilities Management Authority should take the form of a contracting organisation with financial responsibility for all UK civil nuclear liabilities, as well as BNFL's commercial activity.
- Government's decision to break up BNFL, selling off assets and winding up its British Nuclear Group, demonstrated that tackling the nuclear liability now took precedence over the existence of a national champion, or even, arguably, extracting maximum value from the company.
- The Nuclear Decommissioning Authority (NDA) was created in 2005 to bring renewed focus on decommissioning, using competitions for the ownership and management in Parent Body Organisations of the Site Licensed Companies, which under contract to the NDA are responsible for the delivery of site programmes.
- It proved difficult to incentivise contractors effectively, and move away from cost-plus contracts, given the difficulty of establishing the baseline of work to be done at each site.
- Funding. The 2002 White Paper consulted on alternative mechanisms to fund liabilities work; a segregated fund or statutory segregated account to secure flexibility and a long-term funding framework. Although the NDA's budget was ultimately set through the normal Spending Review process, spending on the highest priorities has been protected. and some long term contracts signed

The UKAEA develops a new focus on liabilities management

7.1 The emergence of a new approach to liabilities management evolved out of the practices of the UKAEA in the 1990s. As seen in previous chapters, the UKAEA had become primarily a liabilities management organization, with the end of the UK Fast Reactor programme, and the severe curtailment of its other research work. Furthermore, rather than itself seeking to address its liabilities and developing in house the capacity to undertake decommissioning, the UKAEA had sought instead to outsource the programmes – by 2002 70% of its budget was contracted out. The policy was ‘to involve the private sector to the maximum extent allowed by regulatory requirements on the basis that this drives down costs and encourages the injection of technical and management skills, new ideas and best practice from elsewhere.’[98]The NII had quite serious reservations about the capability within the UKAEA to be an effective site licence-holder under these circumstances,[99] but the model proved attractive to Government as the decade wore on. [100]

7.2 By turn of the century, this approach was seen to have achieved significant successes; the undiscounted cost of its liabilities had been reduced from £9.8 billion in 1994/95 to £7.9 billion.[101] The management team, which had been brought in since the transition from an organization focused on research to one focused on liabilities, was seen to have made headway in implementing the new approach. The Quinquennial Review’s (QQR) survey of the UKAEA’s contractors found that it was ‘well ahead of the rest of the public sector in its approach to contracting and compares favourably with the private sector’, and was ‘committed to continuous improvement’.[102]The review concluded that ‘the new management team has brought relevant commercial experience and the sort of commercial operating culture which seems to us an essential requirement for any organisation whose core skills necessarily include programme management, procurement and the development of customized innovative contracting strategies’.[103]

BNFL remains focussed on its role as a national champion, and looks to privatisation

7.3 By contrast, the focus of BNFL in the 1990s had been resolutely on commercial success. After 1996, BNFL introduced a strategy focused on

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[98] Quinquennial Review of the UKAEA, (QQR), p. 29
[99] Interview evidence
[100] The UKAEA model was endorsed by the 2001 Quinquennial review, and then taken forward as the basis for the Liabilities Management Authority in the 2002 White Paper, *Managing the Nuclear Legacy.*
[101] QQR, p. 29.
[102] QQR p. 34.
[103] QQR, p.30.

international expansion, seeking to cut costs and compete on cost efficiency. Even by the late 1990s, BNFL had not seen liabilities management or clean up as a core activity; one senior manager noted that during this period 'there wasn't really an organisation that was…. focusing on actually cleaning up BNFL's liabilities at Sellafield'.[104] The overall objective for the organization at this time was to move towards privatization. The pressure to address the liability issue was ultimately given traction by BNFL's primary driver – privatization. As commercial advisors assessed the likely value of BNFL, the impact of the liabilities had to be taken into account. A major review of all nuclear liabilities undertaken in 1999-2000 resulted in raising the estimate of the total undiscounted cost of addressing all the liabilities over the next 150 years to £34.2 billion – an increase of £7.1 billion (26%) over the previous year. Separately, a study conducted by Bain and Co, who had been appointed by BNFL to assess the liabilities from the point of view of establishing a Public Private Partnership concluded that it would be difficult to put any concrete value on the liabilities.[105] This was a major barrier to any form of privatization which included the liabilities.

Government reviews the strategy and tackling the legacy becomes the overriding priority

7.4 The renewed focus on liabilities was instrumental in the Government's setting of the terms of reference for the UKAEA Quinquennial Review, commissioned in 2000. This was tasked to look not only at 'the way in which UKAEA manages its own liabilities' but also at 'arrangements for the management of public sector nuclear liabilities as a whole – i.e. including those liabilities owned, managed and funded by BNFL.' The result was that the review conclusions were much more wide ranging, the main outcome being the proposal that 'public sector civil nuclear liabilities, including liabilities at civil sites for which MoD has financial responsibility, should be managed by a single, specialist body, directly responsible to Government.' This organization was seen as building on the approach taken by the UKAEA (thereby contrasting sharply with that taken by BNFL), which provided a

[104] T. Morris and N. Malhotra *BNFL and the Restructuring of the Nuclear Industry,* Oxford Centre for Corporate Reputation, 2011, p. 15.
[105] Ibid. p. 32.

‘possible starting point’.[106] However this ‘Liabilities Management Authority’ would be a ‘different organization, focused entirely on liabilities management, with enhanced management skills and a commercial operating culture.’ This was the approach set out by Patricia Hewitt as Secretary of State for DTI in a statement to the House of Commons on 28 November 2001:

> ‘Set up the [a] Liabilities Management Authority responsible for Government’s interest in the discharge of public sector civil nuclear liabilities, both BNFL’s and the UKAEA’s. The LMA will work in partnership with site licensees – at the outset the UKAEA and BNFL…. to enable the LMA to exercise its role across the whole public sector civil nuclear liabilities portfolio, the Government now propose to take on responsibility for most of BNFL’s nuclear liabilities and associated assets. The most significant of those will be the Sellafield and Magnox sites. Responsibilities for the assets and liabilities associated with BNFL’s commercial fuel, reactor services and international clean up businesses will remain with the company.’[107]

7.5 In July 2002 DTI’s proposals were set out in more detail by the *Managing the Nuclear Legacy* White Paper. This broadly followed the template set out by the Quinquennial Review of the UKAEA – proposing that the LMA should take the form of a contracting organization, with financial responsibility for all the UK’s civil liabilities. In exchange for taking on BNFL’s liabilities, the Government would acquire the funds earmarked for legacy clean-up in BNFL’s Nuclear Liabilities Investment Portfolio (NLIP). The White Paper also indicated that while THORP and the Sellafield MOX Plant were commercial activities, they should also be passed to the new organization, as they were dependent on the other facilities at Sellafield and could only be managed as part of an integrated site. The effect was that the new LMA would take responsibility for BNFL’s main UK assets – both at Sellafield, and the Magnox power stations.

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[106] QQR, p.9

[107] House of Commons *Debates*, 28 November 2001 (375), colums 990-1005

The rationale for creating the Nuclear Decommissioning Authority (NDA)

7.6 The rationale for the creation of the NDA (as the LMA was re-named) was that it would provide a dedicated focus to tackling decommissioning. This applied particularly to BNFL, which had been focussed on commercial activity, but there was also a sense that the clean-up work undertaken by the UKAEA had not received sufficient attention within Government. The view was that the creation of a single contracting organisation would create a competitive market, stimulating innovation, develop supply chains and capture the maximum improvement in performance for the delivery of the clean up programme. This contrasted to the approach taken by BNFL, which had been to develop solutions for tackling the legacy in house (contractors were brought in to deliver a significant proportion of the projects at Sellafield, but the distinction was that the solution was developed by BNFL, and could not be the result of innovation by the contractor).[108] BNFL's approach could be seen to have echoes of the original failures of the UK nuclear power programme in pursuing its own in house technology, rather than adopting the most cost effective approach. Instead *Managing the Nuclear Legacy* adopted the approach taken by the UKAEA. Similarly we have heard from nuclear regulators that it was while examining the work of the UKAEA at Dounreay that they came to the conclusion that the real priority was an integrated decommissioning plan for Sellafield.[109]

7.7 The rejection of the BNFL model for managing liabilities was probably influenced by the company's own problems at this time. There were two relevant issues. First, its US arm BNFL Inc, which had been competing for US clean-up contracts, sustained heavy losses on fixed price contracts[110]and, second, it had falsified some of the inspection data on MOX fuel sent to Japan from its prototype MOX plant.[111] Both of these events caused substantial financial and some reputational harm to BNFL at a critical time for the company.

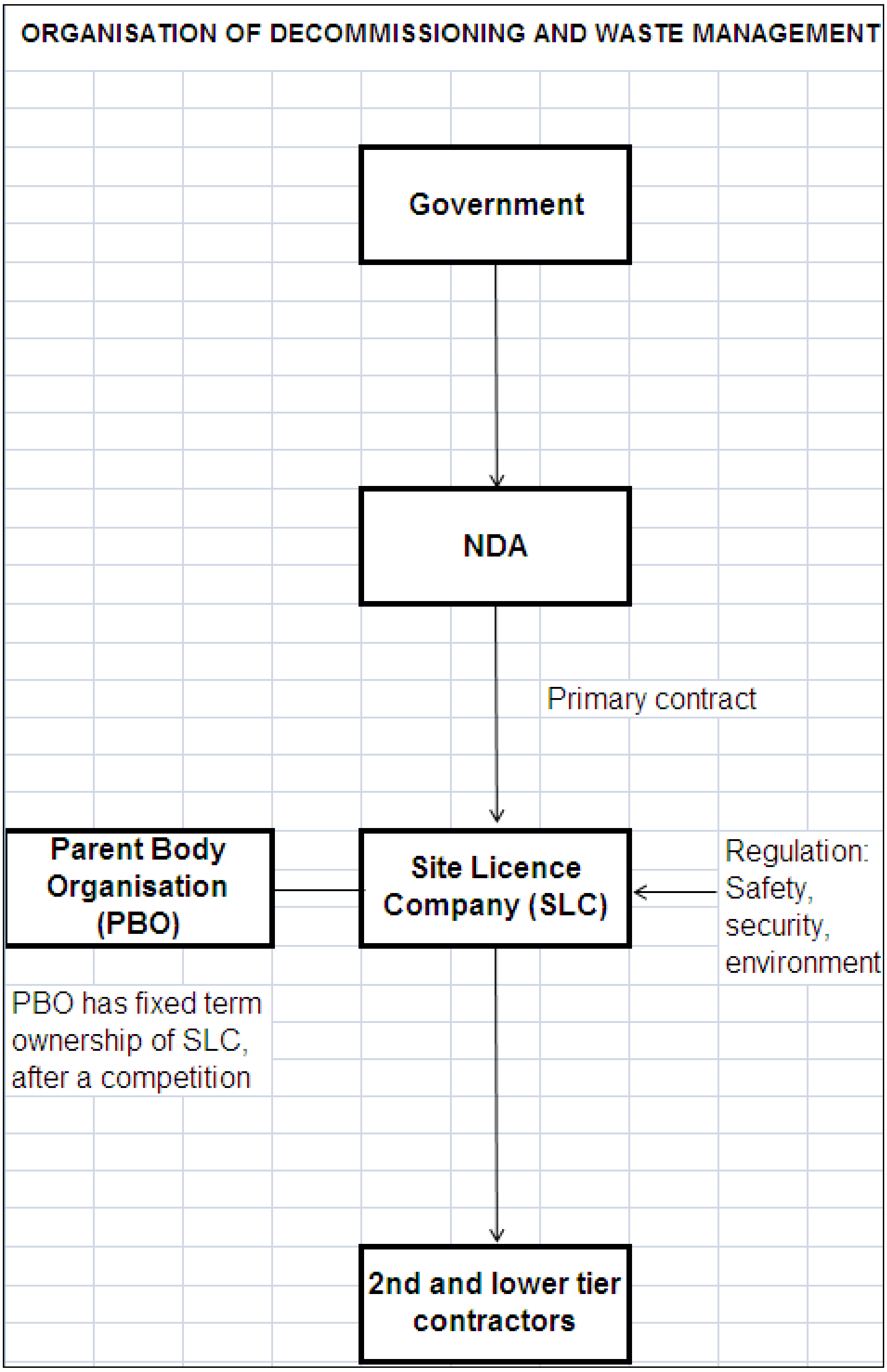
[108] Interview evidence
[109] *A short history of the NII*, p.27.
[110] Morris and Malhotra, p.28..
[111] Ibid, p. 19.

The NDA contracting model

7.8 The aim of the NDA model was to establish a strategic body, accountable to Government, focused on delivering decommissioning and waste management in a robust way. As an arms length Non Departmental Public Body, the NDA has commercial skills and experience not normally held by Government departments, along with a degree of separation from political pressures. The basis of the model was to allow the competitive tendering of contracts to manage and deliver decommissioning of the legacy sites owned by the NDA in the most cost-effective way. This would allow scope for innovation, within the constraints of regulatory requirements for safety and security.

7.9 The vast majority of the existing BNFL and UKAEA staff at each site was separated off into permanent 'Site Licensed Companies' (SLCs), which operate the sites on behalf of the NDA, employing a combined workforce of 18,000. This ensured that existing skills and corporate knowledge were retained, and met an HSE requirement that the Site Licensee should be the 'controlling mind', with direct responsibility for taking the critical decisions. As we have seen, this requirement had been a source of tension between regulators and the UKAEA, when it sought to contract out decommissioning work (whilst itself retaining the site licences) in the 1990s. The NDA competes contracts for 'Parent Body Organisations' (PBOs) which own the shares in the SLC for the period of their contract, with break points which the NDA can exercise. The NDA continues to own the assets, and the liabilities. The PBO contracts create incentives for the parent body to improve the performance of the SLCs against their lifetime plans through seconding in senior managers to improve delivery and innovation.

7.10 The Site Licensed Companies can, where they consider it would be cost-effective, sub-contract work to other companies to complete specific pieces of work. The NDA holds the SLCs / PBOs responsible for delivery against the lifetime plans, and therefore the SLCs are incentivised to negotiate effective incentivised contracts for lower tier contractors.



The breakup of BNFL and British Nuclear Group (BNG)

7.11 The ultimate fate of BNFL illustrated the extent to which the new institutional structure ensured that tackling liabilities would now take precedence over the success of BNFL as a national champion in the nuclear sector. At the time of her statement to the House, Patricia Hewitt had made clear that the option of BNFL becoming a Public Private Partnership could ‘in the right circumstances, be right for BNFL’s business and improve the management of liabilities at Sellafield’.[112]However, the onus was now on the most effective way of managing the liabilities, not on extracting the greatest possible value from the company. The Government carried out a strategic review of BNFL in 2003, and against the strong opposition of the company’s board,[113] came to the view that a public flotation was ‘unlikely to be a realistic option or in the best interests of the taxpayers, as it would reduce the NDA’s flexibility to compete the management of those sites it intended to inherit’.[114] The possibility of trying to retain a strong British nuclear champion was therefore rejected in favour of a more open competition to run UK decommissioning programmes, on the basis that the latter route was the best course to minimise the liabilities and manage them effectively. BNFL’s standing as a national champion had in any case been seriously damaged both by the large losses in BNFL Inc and by the data falsification incident. The Government now instructed the BNFL board to wind down the company piece by piece – extracting significant value, particularly from the sale of Westinghouse (as has been detailed in Chapter 6).

7.12 The break up and wind down of British Nuclear Group (BNG), the element of BNFL responsible for managing the British nuclear sites, also illustrated the extent to which the new structure prioritised effectiveness in tackling the liabilities as the primary objective. The initial preference of the BNFL board was that BNG should be sold as a unit. The fledgling NDA was opposed to this course, as it had concerns that installing a new incumbent in place of BNFL would undermine its plans to introduce competition for the management of the SLCs. The preference of the safety regulator – the NII – was to maintain stability at Sellafield – if necessary through the sale of BNG. In effect the value of BNG was now in the NDA contracts that it held, so a sale of BNG would be equivalent to competing ownership of the contracts. Furthermore the NDA was reluctant to extend its contract with BNG for

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[112] Morris and Malhotra, op. cit., p. 37.
[113] Ibid. The study, based on the evidence of anonymous interviews with senior BNFL executives describes a meeting in June 2003 where ‘the apocryphal ‘full and frank’ exchange of views between the parties took place.’ p. 49.
[114] Ibid, p. 52.

Sellafield (due to expire in 2010) to allow a new owner a longer period before facing a competition.

7.13 BNFL carried out market testing to assess the interest in purchasing BNG. However, the main feedback was that potential bidders would mostly be consortia and that they were interested in breaking the group into its individual parts. BNFL subsequently decided that they would extract the greatest value from BNG if they were to sell the parts individually. However, while there was interest in purchasing the Magnox and research elements of BNG, it was the view of the BNFL Board that there would be little interest from potential bidders for the Sellafield division (BNG Sellafield). This most likely reflects a number of issues, including the uncertainty around the task at the site (Legacy Ponds and Silos had not then been characterised and costed), regulatory concerns about the site and the poor reputation of the Sellafield management. Market concerns would have been particularly exacerbated by the fact that the NDA took the view that it could not offer an extended contract to a new owner of BNG Sellafield without compromising its own mission and possibly breaching EU procurement rules. We have been told that there were tensions within BNFL as the decision to split up BNG and wind-down BNG Sellafield was reached. We have not made a detailed study of the process, but the wind down of the company appears understandably to have been a traumatic process for the management. It seems likely that this will have contributed to a lack of confidence from Government and regulators in the continued ability of BNFL to serve as an effective PBO at NDA sites.

7.14 As the BNFL disposal strategy developed towards a piecemeal sale, but with a policy of "hold and fold" for BNG Sellafield, the regulators became concerned that the existing management would no longer have a stake in the group's ongoing performance. With the expectation that another company would take over the management in 2014, the ablest people might leave. This led to the NDA agreeing to move forward the start of the Sellafield competition to 2007, though this would require a cost-plus, rather than a fixed price contract to be adopted (see discussion in paras 7.17-7.18 below).

7.15 The Government's approach had changed from a position where in the 1980s and 90s it might have prioritised the value of BNFL as a company to the taxpayer, or in the 1950s and 60s – where the priority had been to support the military programme, and subsequently to have a lead in the global nuclear industry – to instead making effective management of the UK's liabilities the primary objective.

The challenge in establishing a baseline for competitive tendering

7.16 An essential feature of the new contracting process was to establish a clear baseline for the work necessary to decommission the liabilities. BNFL had included provision for these costs on its balance sheets, and a number of assessments of the value of the liabilities had been carried out. However, there were no detailed lifetime plans for the necessary work which could serve as a baseline for tendering the role of PBO, for managing an SLC for a period of years, or enabling the winning contractor to be paid by performance. The NDA's first annual report noted that 'one of the biggest issues we face is the limited information we have for a number of the legacy facilities. The challenge is often not how to tackle a particular task but rather deciding what exactly has to be done. For instance, some facilities have neither detailed inventories of waste nor records of how the site was used. Some do not have reliable design drawings that can guide the decommissioning process.'[115]This therefore shaped the first priority set out in the NDA's first strategy document in 2006, to 'create robust, costed and funded plans to clean up sites based on a comprehensive understanding of the liabilities.'[116]

7.17 Moving the Sellafield competition forwards was not ideal from the NDA's perspective, as the lack of characterisation of the work needed – particularly on the high hazard Legacy Ponds and Silos- meant that it did not have a robust lifetime plan against which to measure a contractor's performance. In this case, potential best value for money in a more effective competition was sacrificed to the necessity of putting effective management rapidly in place to address the high hazard facilities. The significance of

[115] NDA A*nnual Report, 2004-05*, p. 6.
[116] NDA *Strategy* 2006, p. 7.

addressing the Legacy Ponds and Silos at Sellafield was similarly to be emphasised in the NDA's 2010 Spending Review Settlement, where it was stated that work on the high hazard facilities was 'protected' in other words, Government would provide the funding to decommission the facilities as quickly as could be achieved.[117]

Approach to funding - a proposed new method of financing the liabilities

7.18 The arrangements to provide for the cost of BNFL's liabilities had been a combination of a portfolio of investments fund that was managed externally (the Nuclear Liabilities Investment Portfolio) and a Government commitment to help meet Magnox liabilities (the Magnox Undertaking - see Chapter 6 for details). By contrast, funding UKAEA liabilities had been undertaken as part of normal Government expenditure through the Spending Review cycle. Expenditure on UKAEA liabilities in the year to 31 March 2002 totalled £277 million.[118]

7.19 *Managing the Nuclear Legacy* included discussion and consultation on possible funding options for the LMA[119] and set out three aims for the future funding of liabilities:

- to underline Government commitment to clean-up and build public confidence in the new management arrangements;
- to give the new Authority the greater flexibility required to drive forward the clean-up process effectively; and
- to encourage competition for contracts by giving companies, and particularly potential new entrants to the market, confidence that funding would be available to support substantial work programmes over a period of years[120].

[117] HM Treasury, *Spending Review 2010*, p. 62.
[118] *Managing the Nuclear Legacy, p. 53*
[119] *Managing the Nuclear Legacy*, Chapter 6
[120] Ibid para. 6.8

7.20 The White Paper recognised that managing nuclear liabilities cost effectively required financial flexibility and competent long term planning. It noted that there was ‘some flexibility within the budgetary settlements agreed with funding departments as part of the Spending Review process, but three year settlements [were], almost always, shorter than the timescale for major decommissioning projects’. It also noted that, in the past, nuclear clean up had been seen as a low priority for funding purposes relative to other programmes. The UKAEA experience had been that ‘settlements [had] tended to be the minimum necessary to address safety and environmental needs. Limited funding has been available for other projects’[121].

7.21 It was argued that there was some scope to meet these objectives within the spending review framework – the LMA could be allowed to enter into long term contracts in the expectation of steady state funding beyond the current settlement, or ‘the impact of variations in annual liabilities spend on departments budgets could be smoothed out in some way.’ [122]

7.22 The paper went on to state that the Government was considering two ‘innovative approaches’ to financing nuclear clean up: a ‘segregated fund’, or a ‘statutory segregated account’ [123].

7.23 The White Paper explained that a segregated fund would be akin to a pension fund which holds investments, and could either operate directly under the control of the LMA, or as a separate body with its own board of trustees (that is, along the lines of the Nuclear Liabilities Fund established to meet the liabilities of British Energy described in Chapter 6).The assets of the NLIP would provide the initial endowment, when BNFL was restructured, augmented by surpluses from commercial operations and ‘annual payments by Government voted by Parliament’ through the normal supply process which ‘would be set at levels which ensured that the fund was maintained within defined limits reflecting the LMA’s future spending projections. The LMA would… then be able to plan its operations with the confidence that

[121] Ibid para 6.7
[122] Ibid para 6.10
[123] Ibid paras 6.11, 6.27

funding was available'. The proposal would therefore have provided a guarantee that funding would be available for decommissioning projects – and, for example, that work would not need to be cut back should commercial income fall short of expectations. *Managing the Nuclear Legacy* did not discuss the implications for value for money of different timescales for carrying out decommissioning work, or the required level of payments from the Consolidated Fund which would be required.

7.24 The alternative of a 'statutory segregated account' would be a 'savings account' kept by the Treasury at the Bank of England, and could only be spent on clean up.. It would similarly have been credited with the value of the assets in the NLIP, and would be topped up by credits to maintain the fund at a level to meet the LMA's projected schedule of decommissioning work.[124] The effect would again be that decommissioning work would have a degree of independence from fluctuations in commercial income, and from Spending Review settlements.

7.25 In the end, neither the segregated account nor the segregated fund was implemented. Given the size of the liabilities, any fund or account would have needed to rely on being 'topped up' through Spending Review Rounds. Therefore the LMA would not have been allowed complete independence in determining the pace of decommissioning work. However, the ability to draw on a financial reserve in this way would have allowed medium term flexibility to accelerate work where effective, and manage fluctuations in income, although the benefits of increased flexibility need to be considered against the Government's wider fiscal plans .

Government opts to control NDA budget through the Spending Review, rather than through a segregated fund or account

7.26 The option of establishing a segregated funding system appeared to have been taken forward in the Energy Act 2004, which set up the 'Nuclear

[124] Ibid paras 6.19-6.22

Decommissioning Funding Account (NDFA)'.[125] However, the 'account' did not materialise in the form anticipated by the White Paper, and never came into effective operation. The nominal Nuclear Decommissioning Financing Account (NDFA) set up in the Energy Act contains no cash. It therefore does not have the effect of enabling the NDA to smooth out fluctuations in commercial income, or the ability to alter the pace of decommissioning to enhance value for money, which would offer a degree of independence from the SR settlement.

7.27 Instead, the approach taken was that the most appropriate funding mechanism for NDA was to provide ring-fenced funding from within the budget of the (then) Department for Trade and Industry's (currently through the Department of Energy and Climate Change's budget).The NDA was therefore required to abide by budgets set through the normal Spending Review process.

7.28 Prior to the 2010 Spending Review settlement, the Treasury allowed Departments to smooth out fluctuations in their spending under 'End Year Flexibility' (EYF). This in principle allowed limited funding which had not been spent in one financial year to be rolled over into the next. The NDA accumulated a reserve under EYF of around £1 billion.– largely due to commercial income exceeding expectations. This in principle gave the NDA a degree of flexibility, though it appears that very little of it was used and the cumulative total was lost at the demise of the EYF system after the 2010 review.

7.29 Under the new rules, government departments and agencies have a small amount of flexibility to move funds between years. In the NDA's case, this would be the main route to seek to mitigate the effects of future financial volatility over periods too short to be addressed by internal reprioritisation within the NDA or DECC's budget. Exceptionally a department may seek support from the Reserve. Such claims would remain subject to Treasury approval and are limited to genuinely unforeseen contingencies which departments cannot absorb within their Spending Review allocations.

[125] *Energy Act 2004,* pp. 29-30.

7.30 One consequence of the current system is that it encourages conservatism in financial planning as Chapter 8 argues in more detail. The penalties for exceeding a funding allocation are much more severe than those for under-spending. For the NDA, with such a large programme of expenditure on a range of difficult and unpredictable projects, this is an ongoing challenge.

7.31 **SR2010 - Agreement on priorities and funding**[126]

	CSR07			SR10			
In £ millions	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Income forecasts assumed at the time of the SR	1,128	1,228	1,120	867	697	784	873
Direct Government funding (**DEL**)	1,765	1,629	1,705	2,022	2,249	2,215	2,146
Total planned expenditure	2,893	2,857	2,825	2,889	2,946	2,999	3,019

7.32 The 2010 Spending Review followed a review process of options by all the main stakeholders – including DECC, NDA and Treasury – looking at the value for money and affordability of different levels of expenditure. The 2006 Comprehensive Spending Review (CSR) had provided Direct Grant Funding of £1.765 billion in 2008-09, £1.629 billion in 2009-10, and £1.705 billion in 2010-11. The 2010 Spending Review took place under severe fiscal pressure as the Government sought to tackle the budget deficit – with most Departments' budgets being cut by 20–30% over the CSR period. However the NDA was in a peculiar position, due to its dependence on commercial income, forecast to decline from £1.120 billion in 2010-11 to £0.867 billion in 2011-12, and £0.697 billion in 2012-13.

[126] Figures provided by the Government's Shareholder Executive

7.33 The process of examining options also led to a conclusion that the work on the highest hazard facilities at Sellafield was a sufficiently high priority that it should be prioritised and protected.[127] The result was that the Spending Review process led to a rise in the direct Government (DEL) Grant to the NDA, which will reach a peak of £2.249 billion in 2012-13. Taking forecast commercial income into account, the NDA's overall budget will increase year on year over the Spending Review period, from £2.825 billion in 2010-11 to £3.019 billion in 2014-15.

7.34 The outcome of the settlement aimed to ensure that the highest hazard facilities at Sellafield received whatever funding was needed, while also providing sufficient funds to stage competitions for decommissioning Dounreay and the Magnox sites. However, affordability constraints meant that some lower priority work (such as in moving the former UKAEA research sites towards site closure) had to be progressed more slowly. The implications of affordability constraints are discussed in Chapter 8.

Radioactive waste management plans for a Deep Geological Disposal Facility

7.35 The demise of the Nirex proposal for a site near Sellafield (see para. 4.39) in 1997 led to a period of reflection in public radioactive waste policy. . In 1999 a House of Lords Select Committee produced a report[128] on radioactive waste management, which called on Government to develop a clear strategy and timetable for implementation. It emphasized that policy development needed to involve stakeholders:

> "the future policy for nuclear waste management will require public acceptance. Central to this is the need for widespread public consultation before a policy is settled by Government and presented to Parliament for endorsement."

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[127] Spending on these facilities was protected in the 2010 Spending Review Settlement – HM Treasury, *Spending Review 2010*, p. 62.

[128] House of Lords Select Committee on Science and Technology (1999) Third Report: *Management of Nuclear Waste*, Session 1998-1999, HL Paper 41. London: HMSO.

7.36 This was followed by the launch of the Managing Radioactive Waste Safely programme in 2001.[129] The first consultation asked stakeholders how they wanted to be involved in the policy development programme, what they thought the policy should cover (i.e. the scope of the issues) and how they thought Government should develop the policy, including what institutional structures should be put in place. The Government responded by setting up an independent committee (the Committee on Radioactive Waste Management, or CoRWM) to look at radioactive waste management options and recommend to Government which one(s) should be implemented in the UK. After it reported in 2006, Government quickly endorsed its main recommendations for legacy waste: that it should be emplaced in a deep geological repository; that robust storage should precede this; and that the only feasible route to getting political consent was to invite partnership and voluntarism on the part of local communities.[130] Government is now actively seeking to engage with relevant local communities – only those close to Sellafield have yet expressed any potential interest – and hope to have a repository ready for use by 2040, allowing for both political and engineering processes to take as long as may be needed.

7.37 The Scottish Government has taken a different view from that in England and Wales on the subject of long-term management and disposal of wastes at intermediate and high levels. Para. 8.24 analyses this further.

7.38 We heard the view expressed several times during our interviews that an additional reason for the long delays proposed for several decommissioning activities (besides radioactive decay and the desire to put off expenditure not currently necessary) was the observation that the timing of the availability of a repository was uncertain and at best several decades away. This was suggested particularly in relation to reactors. When the 100 and 135 year delay periods were first suggested this was not a justification

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[129] Department of Environment, Food and Rural Affairs (Defra), Department of the Environment Northern Ireland, The National Assembly of Wales, and the Scottish Executive (2001*) Managing Radioactive Waste Safely: Proposals for developing a policy for managing solid radioactive waste in the UK*, London: HMSO.

[130] CoRWM recommended geological disposal for legacy wastes only. Government has subsequently endorsed this idea for new-build wastes as well

offered. However, over time continuing delay in the date when a repository might become available has meant that this has become a more serious argument in relation to reactor dismantling, on the grounds that the costs of managing the reactor liabilities would be greater if cores were dismantled before a repository was available and needed interim storage before disposal. By contrast, where wastes are potentially more mobile and less stable, there has since 1995 been a policy driver to immobilising wastes and packaging them in ways that should be compatible with any feasible future management route.

Conclusions

7.39 It was not until the turn of the century that a real focus on clean-up emerged at the policy level. However by the time of the 2002 White Paper it was clear that a systematic and unified approach to managing the nuclear legacy had become a major Government objective. Two factors helped this process: the evident success of the UKAEA's contractor and competition model, and the damage done to BNFL's ambitions to be a commercial nuclear champion by its losses in the USA and the MOX data falsification.

7.40 The 2002 White Paper recognised the particular problems that would be encountered in developing a major clean-up programme and introduced a coherent institutional structure centred on the NDA, created in 2005. Options for a flexible and segregated form of funding were not followed through. The NDA became subject to standard Spending Review processes with ring-fenced funding from its sponsor Department's budget. The new institution was supported by a significant increase in direct Government funding for decommissioning, with spending on the highest hazards protected.

CHAPTER 8 - ANALYSIS

- Technology choices for reactors and handling Magnox spent fuel, and delays in starting a systematic programme of decommissioning at Sellafield in the 1990s, significantly increased the complexity and cost of decommissioning today. Contributory factors include deterioration of the radioactive wastes and the structure of the facilities containing them so that the Sellafield Legacy Ponds and Silos now need much higher expenditure than would have been necessary if earlier action had been taken.
- The effect of discounting has been seen to influence delays to decommissioning of reactors. However, we do not consider that overall it has been the primary driver – which has more often been affordability constraints in a situation where future expenditure yields no financial benefit. Funding on high hazard facilities is currently protected, so discounting is not an issue there, although it remains a significant factor in assessing the business case for other projects.
- There are two different funding mechanisms for legacy liabilities: the NDA model through DECC's Spending Review settlement; and an independent segregated fund, the Nuclear Liabilities Fund (NLF) for British Energy, which is managed by trustees.
- We were told that there has been a change in regulatory approach, with a move to allow larger short term risks in order to reduce risk overall. This should facilitate more rapid decommissioning and enhanced value for money, relative to previous practices. We saw evidence that this change has started to have an effect.
- NDA's funding settlements since 2005 are a substantial increase in funding for decommissioning, and work on the highest hazards is protected. Nevertheless, affordability (in comparison with other calls on Government spending) and flexibility (between years) affect what can be achieved. The condition of the NDA estate means that around 50% of its budget is spent on fixed costs which do not directly advance decommissioning. So a marginal pound – if it could be found - would produce nearly twice as much direct liability discharge as the average pound currently spent.
- There are examples of sites or projects where good value for money could be obtained from earlier decommissioning, if funding could be found. Bringing forward closure of Harwell and Winfrith, for example, would save money in the long term. In such cases, acceleration would need to be signalled and managed carefully so that the supply chain could gear up.
- The NDA oversees a complex programme with very difficult objectives, high levels of uncertainty and often with long time scales, carried out by tiers of contractors. A constant tension is to meet precise spending targets, balancing potential under and over spends. In the past there have been instances of "stop/start" on projects, some of which have been the result of needing to keep within these precise spending totals. This concern may deter some contractors from applying for decommissioning work. The

penalties for overshooting target expenditure are greater than those for undershooting it, leading to a conservative approach throughout the supply chain. To deal with this, the NDA is currently trialling a new approach of 'over-pressuring', on the basis it is easier to cut back than to start up projects. Although a rational response, there will still be some damage to value for money.

- The success of the NDA/PBO/contractor model in bringing efficiencies and innovation relies on a healthy supply chain. The predictability of funding may affect willingness to compete, but there are other factors, including competition from other industries for people, and the sheer difficulty of working at the complex and remote site at Sellafield. NDA has consulted on these issues, and introduced a new strategy.
- In my view, there is a strong case for regarding decommissioning and waste management as a special case within public spending. Reasons are: the task is huge and long-lasting, but finite; projects are unique and one-off and many face major uncertainties that are difficult to resolve; commercial income is inherently unstable; every extra pound spent could achieve almost twice as much direct decommissioning as the average pound, because of high fixed costs; and there is evidence that extra spending would offer good value for money.

8.1 When decommissioning first began to be discussed in the 1970s, attention focused on what would be the cost and timescales to decommission reactors. While the need to manage the subsequent wastes was also recognized, no serious attention was paid to issues arising from spent fuel or fuel cycle sites, especially Sellafield. Most reactors continued to operate in the 1990s and it only began to be clear, especially after 2000, that the most urgent, expensive and difficult decommissioning and waste management tasks would be at Sellafield, the site where spent fuel from the commercial gas-cooled reactors was always sent. This concentration on Sellafield was in part the result of the fact that reprocessing spent fuel led to the need to manage several new waste streams, but – most important – that the wastes from the early military reactors and early Magnoxes had been poorly managed and neglected, storing up very large and expensive technical problems.

8.2 Since the establishment of the NDA in 2005 there has been, for the first time, a clear and unified focus on the decommissioning issue across the board. This has been accompanied by a level of funding that has both been higher and more consistent than in any previous period, though challenges remain. This chapter brings together analysis derived from the foregoing chapters, starting with some historical questions and then moving on to contemporary issues

Earlier periods

8.3 There were opportunities to tackle the most difficult decommissioning issues systematically well before 2005 - and these were missed. The technical task was always going to be formidable and its associated costs high for a variety of reasons, set out below. In addition, and partly because of the reaction to these difficulties, decisions were taken which meant that the task was postponed. This in turn made the task even more difficult, with large cost consequences.

8.4 Box 8.1 shows the main decisions that affected the scale and cost of the decommissioning task. The late 1940s decision to give priority to developing nuclear weapons capability meant in practice a concentration on gas-cooled reactors fuelled by natural uranium, as these would provide high plutonium yields once fuel was reprocessed. It seems improbable that – given the military objective – other decisions could have been made, though these technologies inevitably meant that there would be complexities in decommissioning as well as high volumes of waste to manage. This early concentration on gas-cooling for reactors was continued into the later 1970s. There were opportunities to choose different reactor technology with lower back end costs, well before this time, and by the 1970s the UK was alone internationally in continuing to build waste-intensive gas-cooled reactors. The commitment to reprocessing of domestic fuel was maintained into the 1990s and 2000s when it had already become clear to the utilities in the early 1980s that it was no longer economic. This directly raised the costs of managing spent fuel well above necessary levels. It also became evident, though not officially acknowledged, that the most important product of reprocessing – plutonium – was a liability, not an asset, as soon as work on FBRs was abandoned in the early 1990s. This would therefore add further to the costs and complexity of managing the legacy. Most other nuclear-using countries abandoned reprocessing after the 1970s and so for both reactor choice and spent fuel management it is therefore plausible to argue that these decisions could have been different.

Box 8.1:Key decisions and processes that have affected back end costs (*Adverse effects that might have been avoided in* ***bold*****)**

1946–1950s Commitment to develop independent UK atomic weapons meant the early nuclear programme, and technology choices, were driven by the need to produce plutonium for military use.

1950s–1990s Spent fuel and wastes were stored in inadequate facilities, without proper inventories or protocols. There was failure to plan long term management of the waste, or ultimate disposal. This could be understood in the context of the 1950s military programme, but became progressively less defensible with each successive decade.

1965 Commitment to AGRs as the second generation nuclear programme substantially influenced liabilities as gas-cooled reactors were inherently more waste-intensive than the light water reactors that were in direct competition.

1971 BNFL was founded as an explicitly commercial organisation, giving it incentives to ignore Sellafield clean-up when several legacy facilities were already abandoned.

Mid 1980s This was the period when decisions were taken to continue reprocessing spent fuel, when it was becoming uneconomic to do so, and no military need existed.

1990 Decisions associated with electricity privatisation had the largest single influence in making the extent of liability costs clear. But at the moment when the scale of liability costs was revealed in the failed attempt to privatise nuclear power – so that the issue was at last visible – the previous funding system for liabilities was terminated without replacement, and BNFL continued to pay little attention to the legacy facilities that have subsequently deteriorated with huge cost implications.

1995-1997 The Nuclear Review was an opportunity to have taken a grip on the legacy issue by creating an NDA-like body in the late 1990s. KPMG considered the case, based on UKAEA experience, BNFL opposed it, and the idea was shelved for several years.

1996 The AGRs and Sizewell B PWR were privatised as British Energy and a segregated fund established. BE was rescued from insolvency in 2002 after the electricity price fell.

2002 *Managing the Nuclear Legacy* White Paper set out new organisational and funding model to deal with decommissioning.

2005 The Nuclear Decommissioning Authority was set up.

2008 British Energy was restructured and sold to EDF, with most of the proceeds used to endow a re-structured a much enlarged segregated account, the Nuclear Liabilities Fund, with investment policy subject to Government controls

8.5 There was a real opportunity to minimize both the complexity and cost of liabilities management in 1990 and over the next few years. It was in the process of privatizing electricity in 1988-90 that it became clear that the cost of dealing with nuclear liabilities would be much higher than had previously been officially acknowledged and that the burden would be especially heavy at Sellafield. And from this time the regulator began to put pressure on BNFL to tackle the most problematic legacy facilities at the Sellafield site. However no serious action followed for several years, and the proposal to set up an NDA-type body in 1997 on the basis of UKAEA experience was put on hold. The explanations for this continuing but avoidable lack of effective action seem to be that:

- BNFL was focused on commercial expansion into a wide range of fuel cycle services internationally, and spending on legacy facilities would have in some cases impacted directly on its profitability and in other cases required other parties (e.g. MoD) to be willing to pay more than hotel costs for liabilities that it owned at the site;
- Government was pressuring BNFL to maximize its return to taxpayers and had a long-term plan to privatise the company. It also did not have knowledge of quite how expensive and difficult it would be to remediate Sellafield;
- Government policy up to 1995 was to avoid treating and packaging wastes until a geological disposal facility was going to be available. This was partially modified in a 1995 White Paper on waste, after which a new system encouraged the immobilization and packaging of some wastes;
- Nuclear Electric and Scottish Nuclear Ltd were under pressure to reduce costs. In reviews of decommissioning strategy, NE proposed lengthening the period before final decommissioning, which reduced the size of provisions in their accounts, but was questioned by the NII in their Quinquennial Review.

8.6 Among the influences on the management of spent fuel and wastes at Sellafield, we heard the view that the miners' strike in the mid-1980s contributed substantially to the problems now evident at the Legacy Ponds and Silos. This was apparently due to the need to receive spent fuel from Magnox reactors at a faster rate than previously planned, resulting in unavoidable complications in the storage process. However, while this episode may have made the immediate management problem more difficult, there seems no evidence that it was responsible in any significant way for the problems now encountered, given the long-term neglect of Legacy Ponds and Silos both before the strike and for a long period thereafter.

8.7 There was one exception to this story of continuing inactivity. The UKAEA, from 1994 became (with the exception of its nuclear fusion programme) a dedicated decommissioning agency rather than an R&D organisation. It started a programme of systematic decommissioning at sites such as Harwell, Winfrith and Dounreay. In implementing this approach, the UKAEA adopted a contractor and competition model which later strongly influenced the process of setting up the NDA. NII were at the time critical of the UKAEA's implementation of this programme, on the basis that as the site licensee, they were not maintaining sufficient control over sites, though there were clear efficiency benefits available in the new model.

8.8 Over the last twenty years it has become evident that the most pressing issue in dealing with the UK nuclear legacy is at the large and complex fuel cycle site at Sellafield. There are many other sites which need remediation, including the Magnox reactors, nearly all of which are now shut down. But the cost and complexity of managing Sellafield has, bit by bit, become increasingly dominant, so that in the recent Annual Report from the NDA, the estimate of the discounted cost of Sellafield has now reached £32.7 billion, or almost exactly two-thirds of the total cost of remediating the whole NDA estate.

An attempted counterfactual

8.9 It is clear that the costs of remediating the Sellafield site – particularly the Legacy Ponds and Silos - are now higher than they would have been had serious action been taken starting in 1990. The question then is: how much higher? There are several components that might be expected to lead to higher costs now (at the prices of any one year i.e. ignoring general inflation). These components are:

- Deterioration in the condition of the radioactive materials contained in the Legacy Ponds and Silos, for example the formation of sludges in pools, which complicates the removal and packaging of wastes;
- Deterioration in the structures containing the wastes;
- The large 'hotel costs' incurred in the intervening 20 years or so - that is the costs required to keep the materials and their structures safe and secure;
- Regulatory standards have become somewhat more stringent in the area of radiation exposure.

8.10 It is not possible to quantify the extent of the increases in costs consequent on these four factors. This is both because there is no reliable estimate of what the cost would have been if serious work had started in 1990 and because the complexity of the Sellafield site means that it is not possible fully to disentangle hotel costs[131] for the Legacy Ponds and Silos from other hotel costs on site. Nevertheless it is plain that the costs of fully decommissioning these facilities starting from the period after 2005 will be very much higher than would have been the case if a start had been made in 1990, almost certainly (in my judgement) by several billions of pounds. Work is now proceeding on the remediation of these legacy facilities without financial constraint, indicating that lessons have been learned from this experience.

[131] Hotel costs are those costs necessarily incurred to maintain facilities in a steady state i.e. to avoid further deterioration and increases in the level of risk (more colloquially those costs needed just to 'tread water'.) They are influenced by the regulatory requirements for licensed nuclear sites

The history of liabilities funding

8.11 The history of funding decommissioning and waste management has been poor and far from transparent, reflecting a lack of seriousness in policy terms. Substantial funds collected, and for brief periods managed, explicitly for the purpose of funding decommissioning and waste management have mostly been used for quite different purposes: often they have been added to the Treasury's Consolidated Fund along with other receipts from Government asset sales. Thus:

- Funds collected from consumers for back end liabilities between 1976 and 1988 by the UK utilities, including their share of decommissioning BNFL facilities were 'lost' at the time of electricity privatisation (some £3.9 billion) because the assets in which the funds were invested either went to non-nuclear companies at privatisation or were unprofitable;

- The Fossil Fuel Levy (1990-1996) raised over £6 billion for Nuclear Electric and while this was not primarily intended for use in liability discharge, it allowed BE to generate surplus cash of £2.6 billion which was earmarked for liability discharge by a transfer to Magnox Electric and thereafter to BNFL's Nuclear Liabilities Investment Portfolio (NLIP). When Government decided to fund the decommissioning of the legacy sites from the public purse, the balance of the NLIP was absorbed into the Consolidated Fund after the Magnox sites were transferred to the NDA ;

- A separate Undertaking from Government to Magnox Electric in 1996, valued at £3.8 billion for back-end expenses and due to start being paid from 2008, was in practice an accounting method designed to allow BNFL to trade legally. It was 'extinguished' as BNFL was broken up (though Government similarly guarantees future payments to NDA though without naming specific numbers).

8.12 More positively, the UKAEA was funded to undertake substantial decommissioning directly by Government from the early 1990s at a rate of

£250 million to £300 million annually.[132] Since 2005 the picture has substantially changed, with Government funding the NDA to the extent of £7.7 billion from 2005-6 to 2010-11[133], rising to £8.6 billion in the SR2010 period.

Discounting future costs

8.13 The rationale and process of discounting nuclear liabilities and investment is outlined in Box 8.2 and its possible impact is discussed below. Box 8.3 illustrates the effect of discounting on nuclear liability estimates.

Box 8.2: Discounting and Rates of Return in the Context of Nuclear Waste and Decommissioning Costs

An important issue in the economics and accounting for nuclear power is establishing an appropriate basis for comparing expenditures and revenues over time. In comparison to other electricity generation technologies the issue is particularly relevant for nuclear, given long timescales from the construction of new plant to the completion of decommissioning and waste management, and in absolute terms, the much higher costs associated with the back-end activities.

Since the early 1960s it has been common practice in the public and private sectors to use the technique of 'discounting' to compare the costs and benefits that occur in different time periods by converting them to 'present values', conventionally expressing discount rates (as throughout this box) net of inflation i.e. in the prices of one year. The choice of discount rate therefore becomes important as it will determine the balance of weight given to near and distant cash flows. In practice, the rate will be determined by the purpose for which the discounting is required. For example, it is important to distinguish between a discount rate for public sector appraisal purposes (reflecting social time preference), a discount rate for general accounting provisions in the public sector, and a fund accumulation rate, which is conceptually and practically quite different, but important for private sector segregated funds.

Discounting for project appraisal purposes

In the private sector, the theoretically appropriate post-tax real discount rate for investment appraisal purposes is the 'cost of capital', implied by the costs of debt and equity in capital markets. In studies on the economics of investment in nuclear power, an indicative figure of around 10% is often used. This rate can be used for example to calculate the Net Present Value (NPV) of investment in new generating plant or the levelised cost of generation i.e. the discounted lifetime cost of operating the plant converted into an equivalent unit cost of generation in £/MWh or p/kWh.

[132] UKAEA *Annual Report and Accounts, 2002-3*, p32, and 2004-5, p. 59.
[133] Figures for 2005-6 to 2009-2010 are the actual outturn numbers, while those for 2010-2011 are those planned in the Spending Review 2007.

In appraising central government policies, programmes or investments by nationalised industries, discounting is based on the different principle that society attaches more value to the present as opposed to the future, commonly referred to as 'time preference'. The Social Time Preference Rate (STPR) for discounting costs and benefits in public sector appraisals is specified in the UK by HM Treasury, most recently in the 2003 Green Book[134]. It is set at 3.5% in real terms, with a schedule of progressively lower rates for the longer-term (beyond 30 years) to reflect increasing uncertainty about the distant future.[135] The 3.5% (declining) rate would therefore be appropriate for a public sector economic analysis of the costs of decommissioning and waste.

Government accounting: general provisions

The long term decommissioning and waste management costs of nuclear plant are of such a magnitude and potential future duration that it has long been recognised that special treatment should be given to them, whether the nuclear generator is in the private or public sector. In principle, this should primarily ensure that funding will be available when it is needed, without disruptive or commercially unrealistic demands on corporate or government budgets.

In government accounting, the term discount rate can therefore also be used in a different sense, to describe the interest rate that should be used to value 'provisions' for future liabilities in a department's balance sheet. The concept is therefore closer to the rate of return on a real or hypothetical fund to pay for the expected future commitment. HM Treasury explicitly regards long-term nuclear decommissioning liabilities as 'general provisions', for which its current standard convention is a real discount rate of 2.2%, determined with reference to the real return on index-linked Gilts.[136] This 2.2% general provisions rate is adopted by the Nuclear Decommissioning Authority in their accounts.

The rate of return on a waste and decommissioning fund

While the general provisions rate is meant to reflect low-risk returns, the issue is slightly different, though related, when the context is a genuine fund that accumulates cash to pay for future liabilities. British Energy (BE) in the private sector, for which a fund exists (the NLF) has adopted a rate for its liabilities of 3%. This should be seen as a 'fund accumulation' rate and the value of 3% reflects a broad consensus that this is the level of average annual return on low-risk investment that can be earned. The great bulk of the NLF must at present be invested in the National Loans Fund, currently earns less than 3% p.a. and is taxed. Use of a fund accumulation rate is appropriate in particular for calculating the contributions that should be made to the fund by the generator during the operational life of the plant.

[134] HM Treasury, 2003 *The Green Book,* Appraisal and Evaluation in Central Government,
[135] See Annex 6 of ibid.
[136] HM Treasury, 2004*, Guidance on managing the change in the discount rates for pensions and other long term liabilities*, PES Paper 04

8.14 When any future activity involves expenditure but no income, there is an obvious incentive to delay the expenditure. In addition, any positive discount rate gives a formal incentive to delay future activities as far into the future as possible because the present value of that expenditure continuously diminishes the further into the future that expenditure is postponed. While the discount rates used in the past by the public bodies owning the liabilities were used to justify delaying decommissioning in the case of reactors, it is unlikely that they were the primary driver in influencing them to delay decommissioning programmes. A more significant factor has been broader considerations of affordability in the context of competing claims for expenditure. Different values of the discount rate in the past would probably have made little significant difference to resource allocation decisions on liabilities overall, though the exception may be in reactor decommissioning, where discounting even at low rates made the present value of the cost appear very small when the delay was expected to be 100 or 135 years. However, discounted financial analyses can also be used to legitimise decisions driven by affordability or other considerations.

8.15 In practice, policies – deriving initially from utilities and later endorsed by government – have been to delay decommissioning plans, often into the long distant future. The rationales for such delays, which are much longer than those contemplated by most other countries using nuclear power (see Box 2.1 in Chapter 2) have often involved the idea that radioactive decay would make some tasks easier in the future. Another rationale is that there is no point (and possibly added cost and risk) if structures are dismantled and resulting wastes packaged when there is no final management route for them, such as a deep geological repository. This is in addition to an understandable reluctance on the part of Government to sanction public spending on activities that bring no future income - unless there are other pressing reasons to proceed. While discounted figures are valuable for accounting and financial purposes they conceal information about the extent of decommissioning work and its progress over time, and in the next chapter observations are made about publishing undiscounted numbers as well as the discounted numbers currently available.

8.16 The current NDA funding settlement protects funding for tackling the high hazard facilities – so discounting is clearly not a factor influencing the speed of decommissioning on such projects. However, the discount rate applied continues to influence the assessment of the business case for other projects – this case being framed in terms of net present values. Clearly in this respect the discount rate used will influence assessments of value for money.

Box 8.3 Illustrative Example of Discounting Nuclear Liability Estimates (NLE)

The table below provides an illustrative example of the effect of discounting nuclear liabilities estimates over a period of 100 years, with an assumed profile of spend in which 50% of costs are spent in the first 20 years, 30% in the next 60 years, and 20% in the final 20 years. The table also demonstrates the effect of discounting £100 billion of nuclear liabilities at different discount rates.

Illustrative example of the effect of discounting NLE at different discount rates

	Undiscounted £bn	**Discounted (1%) £bn**	**Discounted (2.2%) £bn**	**Discounted (3.5%) £bn**
Nuclear Liabilities Estimate	100.0	73.8	57.0	46.8

The NDA ARA 2005/06[137] outlined the approach used to derive the then discounted nuclear provision figure of £30.6 billion in the financial statements of 31 March 2006. The starting point for the discounted provision estimate was the undiscounted sum of the Life Cycle Baseline (LCBL) estimate for each site, which stood at £62.7 billion as at 1 April 2005, as published in March 2006. After a number of largely technical adjustments, the £62.7 bn. number was reduced to an undiscounted total of £53.3 billion, After discounting and other minor adjustments, the NDA's discounted provision then stood at £30.6 billion.

Different funding regimes for different liabilities

8.17 Chapter 7 set out the evolution of the funding regimes for the NDA and for British Energy liabilities. If new nuclear power stations are built, there will be three different systems for funding liabilities. It is evident from the rescue of British Energy that should other arrangements fall through, Government ultimately has to take responsibility for paying for nuclear liabilities.

[137] NDA *Annual Report and Accounts 2005/06*, Page 71. http://www.nda.gov.uk/documents/upload/nda_annual_report_accounts_2005_06_1.pdf

Government has been aware of these lessons in seeking to devise a robust funding model for liabilities stemming from new nuclear build.

8.18 Chapter 7 discussed the various options considered by the Government for funding future decommissioning following the *Managing the Nuclear Legacy* White Paper. In practice, the NDA is funded in broadly the same way as mainstream Government expenditure, through the Spending Review Settlement and annual grants in aid from Government. In this respect it follows the model used by the UKAEA in the 1990s. By contrast British Energy, when the AGR and PWR power stations were privatized in 1996, funded at least some of its liabilities through a genuine segregated fund – the Nuclear Liabilities Fund (NLF), with BE making regular payments, and having responsibility for meeting any residual liability. Following the rescue, restructuring and sale of British Energy, Government accepted responsibility for funding any residual liability, should the NLF prove insufficient. Government also effectively became more influential – it appointed the majority of the fund's trustees and the Office of National Statistics classified the fund as a public body. From this point onwards the fund has been invested almost entirely (currently to the extent of almost 90%) in the public sector.

8.19 This takes the form of investing the large majority of its capital in the National Loans Fund. The average rate of return over the life of the fund is one of the key variables that will influence its ability to meet in full the liability it was set up to cover. When interest rates are low – as they currently are (about 0.5% nominal) – the risk that some portion of the future liability will fall to the taxpayer rises. Other key variables, such as the eventual lifetime of the reactor fleet, may decrease that risk.

8.20 The major distinction which remains between the NDA funding regime and the NLF is that expenditure can be sanctioned for the duration of individual projects. This means that decommissioning funded by the NLF will not be subject to annual budget limits and will not need to be negotiated through the Spending Review process. Being able to take a longer term view on decommissioning – at least as long as the funds last - has potential benefits in that it provides the maximum scope to create contracts with incentives to deliver the work in the manner which creates best value for money - including bringing the profile of work forward where it makes sense to do so. Another important distinction is the nature and age of the respective estates. In managing the BE legacy, costs which fall to the NLF should be lower per reactor due to more modern designs and less diversity than across the NDA estate. These distinctions, taken together, should allow greater scope to accelerate work and limit hotel costs.

8.21 The current valuation of the NLF of £8.6 billion is around double the current estimated liability estimate of £4 billion (discounted), though its current rate of accumulation is significantly less than the discount rate applied (3%). The undiscounted value of the fund is around £12 billion. Whether the fund will be able to meet all the BE liabilities will depend on a range of factors (in addition to whether the current approach to its investment regime are maintained), including the variation in UK interest rates, the extent of any life extensions to the AGR fleet, and the degree to which the scale of the liabilities can be successfully managed.

8.22 The risk is that if the fund is insufficient, the advantages of the (segregated) funding model would be lost, there would be a reputational impact in terms of the nuclear sector having been seen not to have ‘paid its way’, and future taxpayers would need to pick up the remaining liability. However, Government sees value, particularly in the present macro-economic climate, in using the NLF to reduce the amount of borrowing that the public sector needs to undertake in the short term, thus somewhat reducing future taxpayer liabilities. It is beyond the scope of this report to assess the relative merits of these approaches to the NLF’s investment policy.

8.23 A final issue concerning the fund is that its structure gives EDF no clear financial incentive to manage down the level of liabilities. This is because none of the expenditure on BE liabilities will affect BE’s bottom line and Government has accepted that it will fund any liabilities which exceed the fund’s value. EDF clearly sees a reputational stake in successfully managing the liability, and we have been told that it is currently cooperating with the

NDA in seeking to exploit synergies with Magnox decommissioning. As also mentioned earlier, NLF NDA and EDF are currently working to improve the financial incentives on EDF

Funding future nuclear liabilities

8.24 Primary and secondary legislation has already been enacted as a framework for the new funding system envisaged for any new-build reactors. The approach will be based on new nuclear operators making payments to an independent fund, which will be required to maintain a value in line with a projection of what is needed to meet the cost of decommissioning and waste management. This will be linked to the lifetime plan of the plant – if the estimated cost of decommissioning goes up the company would be required to top up the fund, whereas if it can show that costs will be lower, it will be permitted to withdraw excess funds. This creates a strong incentive for efficient liability management. Government has been consulting over detailed plans for eventually transferring title to wastes to Government at prices that are intended to protect taxpayers' interests. The system is linked to the idea that a Deep Geological Disposal Facility (GDF) will in due course become available and will take the wastes.

8.25 It is important to note that even where funding is adequate to cover the costs of work to be carried out 100 years or so into the future, the fact that the work still needs to be done at later dates means that it is future real resources, not present-day resources, that will be deployed to carry out the task. This means that future generations are not protected from the consequences of delay – even though the existence of a well-endowed fund may help convince future generations that there is an established property right to deploy their resources to carry out decommissioning ahead of other possible resource uses at that time. The issue of the legitimacy of lengthy and planned delays in decommissioning is beyond the scope of this study, but there are both ethical and pragmatic reasons why Government might wish to consider whether the lengthy delays represent the right timescales.

8.26 Ethically, the issue is passing liabilities to future generations (i.e. not following the 'polluter pays' idea) and pragmatically, the reputation of the nuclear industry in terms of its ability to achieve clean-up, especially in a context of new build, may be significant. Also pragmatically, it is not always the case that the discounted value of liabilities will necessarily be higher if decommissioning timings are brought forward. For example 'hotel costs' for both earlier and later future years will be avoided and in some cases they escalate much more rapidly than the discount rate. On the other hand, some work may be more expensive if undertaken earlier because less radioactive decay will have taken place. It is therefore an empirical question whether or not earlier decommissioning will have higher or lower discounted costs than the currently planned schedule. There is evidence (see below) that in some cases earlier decommissioning than possible under current financial arrangements would be substantially cheaper, on a discounted basis, than postponement.

The effects of regulation

8.27 Arguments are sometimes made that the safety regulatory system sometimes makes legacy management slower and more expensive than would be possible under a different regulatory approach (on the assumption always that this alternative approach would maintain necessary safety standards). We have not found significant evidence of this. The one area where there have been concerns is the idea that regulators (in practice the NII, now absorbed into the wider ONR) have on occasion been unwilling to sanction particular proposals on the grounds that they would lead to a temporary increase in risk – followed, it is argued, by a substantial hazard and risk reduction, thus minimizing the total risk over time. However the view of the regulators is that policy has changed in a subtler way, so that higher short-term risk increases may be allowed because the existing risk, in the absence of remedial action may be rising, and is held to be unacceptable. We saw evidence that this change has begun to have an impact. If it is consistently applied, it should ensure that regulatory action does not unreasonably hamper the decommissioning process or lead to poorer value for money than would be possible for any given level of safety.

The proposed Geological Disposal Facility

8.28 In the medium term a great deal depends, for the completion of the decommissioning and waste management task facing the NDA, on the availability of a disposal route for wastes. NDA now has responsibility for the development of a GDF for this purpose. The expected earliest date for readiness of a repository is 2040, reflecting both the time needed to construct consent and the technical complexities of a large and unique underground construction project. Government has recently challenged NDA to achieve a ten year advance on the 2040 date. Whether this is feasible, and what might be the consequences of attempting to achieve it has been outside our terms of reference, but is a subject that deserves further work.

Scotland

8.29 Whilst the policy for low level radioactive waste is the same across the UK, the Scottish Government takes a different policy view on higher activity waste from that in England and Wales. It rejects the idea of deep geological disposal as an end-point and expects to accommodate all wastes in storage or disposal facilities that are both near-surface and as near to the current location as possible. While the Scottish policy has no immediate effect on liability management in the short term, it could prove significant in the longer term depending on how the policy is implemented. For example, the development of long-term waste facilities at all Scottish sites would probably raise the total UK costs of waste management compared to a more centralised approach, given the economies of scale that would be lost. On the other hand, should Scotland develop a two-site strategy, one at Dounreay and another for the south of Scotland, this effect would be muted

Funding issues

Average and marginal spending

8.30 The NDA's primary mission is to achieve decommissioning, including the associated waste management activities that follow decommissioning. The condition of its estate is such that a substantial portion of its annual spend is devoted simply to maintaining the safe and secure condition of existing sites. These are the so-called 'hotel costs' which are by far the largest component of overall support costs, though an exact breakdown is not currently available within the support cost category. NDA is also responsible for operating a few remaining 'commercial' nuclear facilities for the remaining years of their life (two Magnox stations plus reprocessing and, until very recently, MOX fabrication at Sellafield) and this complicates analysis of its budget.

8.31 NDA divides its expenditure into five broad categories, shown in Table 8.1 below:

Table 8.1: NDA expenditure 2010/2011

Decommissioning and termination	9%
New construction projects	21%
Waste and nuclear materials management	19%
Commercial operations	20%
Support costs	32%

Source: NDA *Annual Report and Accounts 2010/2011*, p. 20

Note: Percentages add up to 101% in original source

8.32 According to the Public Accounts Committee (2008), NDA spent 31% of its budget in 2006/7 on decommissioning project work, though this may not have included the 'new construction' category shown above. The table above shows that by 2010/11 some 49% of NDA's costs (the first three categories) went on activities that are in principle directly reducing the overall liability. There is however some ambiguity in the 'new construction' category where some projects are primarily in support of commercial operations rather than decommissioning and waste management. However the bulk of new construction is unambiguously for decommissioning-related purposes, for example constructing facilities for retrieving radioactive materials from Legacy Ponds and Silos and constructing Intermediate Level Waste stores.

8.33 Despite this ambiguity in relation to the purposes of some new construction, it is still evident that close to only 50% of NDA spending is devoted to directly tackling the legacy. In other words, out of the average pound currently spent on the NDA's primary mission, only around 50p advances this mission directly.

8.34 In the short-term, spending on support and on commercial operations – the other half of the NDA budget - are essentially fixed costs. Therefore availability of extra income would not lead to any further spending on these activities. So an extra or marginal pound spent on NDA – if it could be found - would achieve close to a full pound's worth of decommissioning. This is expenditure which, once undertaken, never recurs. The important corollary is that if NDA spending were reduced, the effect would be disproportionately to impact on decommissioning projects, as it will not be possible to reduce support or commercial costs.

8.35 It is therefore clear that if it were possible to find additional funds, reprioritise spending from elsewhere or generate savings from within the existing budget and accelerate current decommissioning plans, there would be significant scope for reducing the overall cost of the liability. Whether or not such increases in spending would offer good value for money depends on the economics of the projects that could be brought forward, and we return to this below.

Affordability, flexibility and value for money

8.36 The NDA strives to achieve the best possible value for money. In order to achieve this certain conditions would need to be met in an ideal world:

- The NDA would be able to spend as much as it can on projects which offer to minimize total cost – in other words where immediate spending saves a larger amount of (discounted) spending later on (the **affordability** issue);
- The NDA would be able to spend its budget as flexibly as possible, and more efficiently manage volatility between years caused by unexpected over- or under-spends on projects, and/or variation in commercial income (the **flexibility** issue);

- The NDA would also like to maximize the scope for contracting for decommissioning work on a basis as close to fixed prices as possible under a competitive contracting regime, because this should in principle drive down the costs of specific tasks (the **supply chain** issue);

8.37 In the real world, there are necessarily constraints on the achievement of these ambitions.

8.38 The Government's framework sets the parameters for the overall level of public spending. This framework is designed to maintain external confidence in the UK, support macro-economic stability and enable the UK to borrow at low interest rates. To meet its fiscal mandate, the Government must balance competing spending demands and manage expenditure through spending controls. This will, as a consequence, constrain what is affordable and what flexibility is available. Overall annual Government expenditure is therefore an important factor in determining the allocation of resources (not just the lifetime costs for any given project or policy area).

8.39 More specific to the nuclear decommissioning industry are regulatory drivers and constraints. Where, for example, regulators require work to be done on high hazard facilities, the spending, while essential, will not necessarily minimise costs over time, if other work offering good value for money must be deferred. In addition, to expand decommissioning funding on a close to fixed price basis need to take account of issues such as the extent to which decommissioning tasks are clearly defined and technically known, the degree of competition in the supply chain, and the ability of the supply chain to respond if further work is offered.

8.41 The question then is how far, within the parameters of the Spending Review settlement over the next three to four years, might the management of the funding of decommissioning be improved to enable better value for money to be obtained?

8.42 Considering first the **affordability** issue, the funding settlements that NDA have received since 2005 have represented a substantial increase in funding for decommissioning. This represents a radical change from the lack of focus on liabilities under previous management models. The current focus and substantial funding demonstrate that lessons have been learnt, and the existence of detailed lifetime plans for sites shows that the issues which were previously neglected have now been seriously thought through.

8.43 However, despite the increase in funding and focus, the pace at which the NDA can deliver its programme has been constrained by the emerging understanding of the scale of the challenge at Sellafield, as the liabilities there have become better characterised – both revealing the urgency of the work to tackle high hazard facilities, and the scale of the costs involved. NDA originally floated the idea that Magnox stations might be completely decommissioned within 25 years. However, the extent of the issues in relation to the Legacy Ponds and Silos has meant that the NDA has needed to dedicate the majority of its funds to Sellafield, where most of the highest hazards are. Funding of these high hazard facilities has therefore been protected – and as a result, other work across the estate has had to proceed more slowly.

8.44 Nevertheless, tackling the liability remains subject to a broader affordability constraint, and must compete with other calls on Government spending. But despite the significant sums currently earmarked, the NDA is able to identify a number of projects which the evidence suggests would represent strong value for money should funds become available. In other words the total discounted future costs saved would be substantially higher than the short term costs of executing relevant projects, primarily because of the high hotel costs of treading water.

8.45 The result is that projects which it would make sense to accelerate in value for money terms have needed to be constrained for affordability reasons. The clearest (although relatively small-scale) examples are the English research sites – Harwell and Winfrith. Neither site represents as high a risk as found elsewhere, but the need for continued security and maintenance at the sites leads to significant hotel costs and very limited current decommissioning work. The NDA have been clear that they cannot justify spending additional funds on the research sites if the money could instead be spent on the higher hazard facilities at Sellafield. Despite this position the NDA is keeping the approach to Harwell and Winfrith under review, and could move to accelerate them should further funds become available (for example through commercial income exceeding expectations).

8.46 The Magnox sites are a much larger issue relative to the overall NDA budget (Magnox represents some 16% of the total discounted liability) than Harwell and Winfrith. The medium term goal for the Magnox estate is to move each of the facilities into 'care and maintenance', in which they can be safely maintained, if necessary for a prolonged period, prior to final site clearance. The NDA has moved from a broad front approach to moving Magnox sites into care and maintenance, to one focussed on accelerating two sites, while deferring work on other Magnox sites. The main advantages from accelerating two sites are: (i) maximising the opportunity to learn lessons, and develop innovations which can then be applied elsewhere; (ii) bench-marking costs more accurately, so that the scope of the new PBO contract for the Magnox sites is more accurately defined; and (iii) the Magnox SLC is able to concentrate its best staff on the two sites being accelerated, who then move to apply lessons learned to other sites enabling quicker completion. The two site acceleration strategy is therefore expected to deliver substantial benefits, relative to spreading resources more thinly. It also delivers significant short term savings, relative to the NDA's previous baseline, by deferring work elsewhere on the Magnox estate.

8.47 However, the approach is also a response to two constraints: (i) of what was affordable in the context of the last Spending Review, and substantial reductions in Government Expenditure across the board: and (ii) some limitations in the supply chain, which limit the ability to accelerate work across all sites.

8.48 The NDA have provided evidence that if sufficient funds could be devoted over a prolonged period, more progress could be made across the Magnox estate while maintaining the two site acceleration strategy. The result would be earlier site closures (with resulting reductions in hotel costs). Any such acceleration would need to be managed gradually – providing a clear indication that funding would be increased to allow the supply chain time to build up capacity. This approach would need to be managed in parallel with rectifying skills gaps in the labour market. We have been given examples of particular sites which have worked with educational institutions to develop courses tailored to meet the sector's needs.

8.49 On the **flexibility** question, the NDA receives multi-year Spending Review settlements through DECC. We have heard evidence that a multi-year spending settlement provides significantly greater stability of funding than is the case in some other countries – for example, US Government budgets are voted on an annual basis, though their underspends can be carried forward. The multi-year settlement also provides some confidence for the supply chain that funding levels will be maintained. But in line with all public sector bodies, the NDA also needs to manage within an annual budget voted by Parliament, with a very marginal capacity to carry unspent funds over from one year to the next two.

8.51 The interviews we have conducted have suggested that the budgetary cycle impacts on the NDA in several respects.

- First, spending totals create significant pressure for the NDA to precisely hit an annual budget (and particularly not to overspend, which would lead to its accounts being qualified). This is particularly difficult because of the unavoidable variability of the commercial income it relies on and the scale, long duration and uncertainty of the decommissioning work involved. There is still substantial technical uncertainty in the decommissioning work and unforeseeable delays mean that work can be moved from one financial year to the next. This tends to support the need for flexibility within the SR period and from year to year.
- Second, the annual budget cycle can lead to problems where individual projects cross the financial year boundary. We were given an example of one project where poor weather in March led to expenditure being delayed until April. This particular case could proceed because of the NDA's internal system of portfolio management, which reserved an internal 'cushion' to move

money to pressing needs across the estate during the year - but may have meant that expenditure elsewhere was delayed. If NDA had not had this system and scope, there would be further impact in terms of delays;

- Third, lack of flexibility between years, combined with the volatility of commercial income, led to a claim on the Reserve in 2007-8. In this case, NDA were expecting waste substitution income to come through, but the timing was uncertain at the time for bidding for the Supplementary Estimate. There was therefore no choice but to ask for £400 million. In the event, this was not needed, as the payment came through within the financial year. This was not only a bureaucratic process but also led to criticism of the process by the Select Committee with recommendations for change.[138]

8.52 The financial system under which NDA has operated until the new SR therefore was one in which risks were asymmetrical, and it was much safer to under-spend than over-spend. The new system still requires NDA to try and hit the single value of its agreed annual budget though there is some limited flexibility between years. But the instability of the roughly one-third of its income that still comes from commercial sources adds to the problem. The NDA has now revised its budgeting process and is now aiming to spend 103% of its agreed annual budget ('over-pressuring') in the expectation of some slippage. While this strategy is a rational response to the incentives on offer, it is unlikely to be sufficient of itself to ensure NDA can cope with the underlying volatility inherent in managing their overall spending programme and commercial revenues.

8.53 We have also heard that the need to hit an annual budget has had an impact on the kinds of contract which SLCs can offer to Tier 2 contractors. The best value for money approach could be for the SLC to be able to offer a multi-year contract, with the contractor being given full flexibility to innovate to deliver the cheapest and quickest approach to delivering a project. However, the SLCs also have annual budgets within the overall NDA envelope. This means that offering flexible multi-year contracts entails a risk that were

[138] House of Commons Business and Enterprise Committee, *Funding the Nuclear Decommissioning Authority*, Fourth Report of Session 2007-08

contractors to bring forward their profile of spend (even if the result is to deliver the overall project more quickly and cheaper), the SLC might not be able to hit its annual budget. The NDA has been working with SLCs to develop approaches to mitigate this issue – with the SLC balancing the risk of contracts across its portfolio, enabling project profiles to be adjusted where this would deliver a better result. However clearly such an approach is more challenging to deliver than one where funding could be allocated to an individual project, with the contractor being able to determine the profile of spend.

8.54 Finally on the **contractual and supply chain** issue, the introduction of the NDA-PBO/SLC-contractor model has the objective of introducing competition. This should enable the NDA to draw on a wider international pool of expertise in decommissioning, innovation and programme/project management, and thus achieve better overall value for money. We have heard consistently, both from the NDA and the private sector, that there is strong interest in NDA PBO contracts: each PBO competition so far has been strongly fought, though the present competition for the Dounreay PBO contract has only two bidders. We have also heard (again both from NDA and the private sector[139]) that there have been problems in attracting interest from Tier 2 suppliers, below the PBO level. This is significant, given SLCs spent £1.8 billion in the supply chain in 2010/11, up from £1 billion in 2005/6. Reasons given for such problems include output specified contracts which constrain supplier innovation, the complexity and difficulty of the task at Sellafield, with restrictive site rules, and a culture that can be hostile to outside contractors or different approaches. But we have also heard that bidding costs, unpredictability of funding, and annual – rather than multi-year - contracts, are negative issues for suppliers and contribute to Tier 2 contracting problems.

8.55 We were given the example of one contractor, which had a contract to deliver a project at Sellafield for the first time, and found that it was unable to

[139] One interviewee told us that the top 5 global engineering firms were not interested in bidding for Tier 2 contracts at Sellafield.

get approval from the SLC for the approaches that they had relied upon to deliver savings on the project against its performance plan. This led to significant losses for the contractor. Clearly there needs to be a balance, and it is necessary that the nuclear regulator should ensure that safety is not compromised. However, the evidence from our interviews suggests that some of these restrictions result in part from a throw-back to attitudes at Sellafield under BNFL – where there was a sense that the site knew best, and that its procedures were always the right ones to follow, rather than from a fully thought through safety analysis.

8.56 A potentially serious supply chain issue is the extent to which it could respond rapidly if the NDA's funding were to increase. Clearly a very rapid increase would be impossible to service, but we received evidence to suggest that at the research sites and at the Magnox sites, a steady and planned increase in spending would elicit an effective supply chain response.

8.57 NDA recognise the importance of a healthy, skilled supply chain, and that while in most cases the market is responsive, they are competing for some niche services in a relatively small pond. This can result in delays or bid up costs. NDA consulted in 2008 on proposals to improve the NDA estate's use of the supply chain, and issued a second supply chain development strategy in 2010. The supply chain for decommissioning at national level remains largely a sub-set of supply chains serving other industries, and some supply chain issues are not related to funding. Nevertheless, the annual basis of funding for most contracts does seem a discouraging factor for Tier 2 contractors and below, and it seems likely that the ambition to move towards fixed price contracts is hampered by the annual constraints on spending that sometimes have to be applied.

Alternative funding systems in future?

8.58 The NDA is now subject to the new spending rules introduced in SR2010. Given the level of ongoing taxpayer support needed to meet decommissioning costs and the contingent liabilities that lie with the

Government, the NDA regime will always be subject to Treasury control and Parliamentary oversight of public expenditure. However, there are elements in the NLF funding system that offer pointers to a potentially more efficient structure for the kind of long-term infrastructure programmes that the NDA are managing. While the NLF system is subject to financial and technical scrutiny (by the fund's trustees and the NDA respectively) there are no annual or other intermediate spending controls, thus allowing contracts for decommissioning and waste projects to be let for their full duration, allowing for improved efficiency and innovation. In my view, it would be worthwhile to reflect on the relative merits of the two systems for 2015 and beyond.

Conclusion: is decommissioning different?

8.59 The policy system made a serious attempt to deal with decommissioning and waste management liabilities only after a long period of virtual inaction. Much more could have been done earlier, at substantially lower total cost to taxpayers. While this delay could appear to be a consequence of the process of discounting – at any positive discount rate a liability will always be worth postponing for as long as possible – in practice discounting served mostly as a legitimating device rather than providing a primary cause of delay. Delay was instead mostly the result of a mixture of circumstances, especially the concern of both Government and BNFL to maximize the profitability of the UK's role in providing global nuclear fuel cycle services; the divided financial responsibilities (between MoD, utilities and BNFL) for the legacy, resulting in a failure of ownership of the problem; and the impact of affordability constraints, especially marked where future expenditure brings no financial benefit

8.60 The analysis in this chapter shows clearly that targeting additional spending (the "marginal" pound argument) on decommissioning would buy about twice as much direct decommissioning work as the average pound, as half of NDA's spending is fixed and does not directly reduce the overall liability. It also shows that there is good evidence that increased spending on the certain areas of the NDA estate would yield good value for money – higher spending on research sites for example would cost substantially less than the discounted cost of currently planned delay. The primary reason for this counter-intuitive result is the avoidance of high hotel costs as a result of early action. Nor do supply chain constraints seem likely to frustrate this result, provided it is signalled and planned for appropriately.

8.61 The analysis also points to the operational and financial challenges faced by the NDA (for example, the incentives for the NDA to land exactly on a particular annual spending target and from the consequential need, at times, for NDA to rein back on individual project spending to ensure it does not breach its approved level of spend).

8.62 But the question might reasonably be asked: so what? Other public agencies are subject to very similar control regimes, which have their own logic in terms of macro-economic budgetary management. Nevertheless, there are reasons to suppose that nuclear liability management *is* a special case. This is because:

- the extent of the overall task is very large indeed and stretches over decades, with individual projects costing in the hundreds of millions of pounds. But NDA spending is also once-for-all. When decommissioning is completed, no further spend is needed, so early increases in spending do not lead, as in some other fields, to an expectation that high levels of spend will continue: rather the reverse is true;
- the poor condition of much of the NDA estate means that it is exceptionally difficult to be sure how much some of the most expensive and high-priority tasks will cost, and over what timescale. Essentially the great bulk of NDA projects are unique and one-off and this hugely raises uncertainty levels, while at the same time the NDA has no explicit allowance for contingency in its financial system;
- the instability of NDA commercial income, as the plants operated are either old and/or unreliable, makes the planning of spending more difficult for the NDA than most other public agencies receiving grant-in-aid moneys;
- building a national supply chain (a task at least as important as attracting high-level knowhow from international firms) is made more difficult as a consequence of the above factors;

- every extra pound spent on the NDA would yield double the amount of direct decommissioning than the average pound, because of high fixed costs.

8.63 It is also arguable that the case for dealing with the nuclear legacy is both ethically sound - a good thing per se - but also important in its effect on the climate in which it would be possible to build the new nuclear power stations. For these reasons, higher spending in a context of a more flexible financial regime would pay real dividends. However it is also important to acknowledge that these claims for decommissioning will need to be balanced against other ‘special case’ claims for public spending and more flexible financial regimes.

CHAPTER 9: LESSONS

9.1 Until the last few years UK policy for nuclear clean-up was characterised by low priority, and delay, as well as funding schemes that have very little effect on discharging liabilities. More recently there has been recognition of the need to focus clearly, and in a unified way, on the clean-up task. Setting up the NDA was a clear step forward as was the large accompanying increase in public liability funding. The principal lessons from this study are set out below.

Past funding regimes and the private sector

9.2 Past funding regimes, notably those established by the utilities prior to 1990 and later and more soundly by BNFL have in the end turned out to pay little or nothing for liability discharge before being abandoned and their proceeds dissipated. Having a robust segregated fund to cover decommissioning costs is designed to ensure that the funds are available when needed, and should enhance public trust. Government's approach to new nuclear stations embodies this approach.

Funding

9.3 It is clear that a marginal pound spent on the NDA will produce around twice as much direct liability discharge as the average pound currently spent. Any possible increases in NDA spend will therefore speed up completing the overall decommissioning task. The most important reason for this is that there are high 'hotel costs' – the costs of simply maintaining sites safely and securely.

9.4 There is evidence that in some areas, accelerating decommissioning through increased funding would be beneficial in net present value terms, by enabling hotel costs to be eliminated earlier. The saved (and discounted) future hotel costs would – e.g. for research sites – substantially outweigh the costs of early action.

9.5 The NDA face a number of operational and financial challenges. While departments and agencies like the NDA have some limited flexibility to carry forward marginal under-spends between years, both the NDA and its contractors still have powerful incentives not to over-spend, even by very small sums. It also appears that the current arrangements impact on the ability of SLCs to provide incentives to contractors to complete projects more quickly (which may also be cheaper) due to the need to match an annual funding profile for each SLC. If in future greater flexibility could be considered ,in the over-spend direction as well as under-spend, this would almost certainly offer good value for money. This is because the need to rein back or accelerate some projects late in the financial year could be reduced, and all funding could be allocated to the projects that represent the best value for money, rather than in part to those which can be turned on or off quickly. There would also be beneficial impacts on the supply chain, including the likelihood that the competitive regime could be sharpened and further value delivered. However, the benefits of increased flexibility need to be considered against the Government's wider fiscal plans. .

9.6 The effect of discounting has been seen to influence delays to the decommissioning of reactors. However we do not consider that, overall, discounting has been the primary driver in leading to decisions to postpone activity – this has more often been a result of general affordability constraints applied in a situation where future expenditure yields no financial benefit. The high hazard facilities currently receive protected funding so discounting is not an issue where they are concerned, although it remains significant in assessing the business case for other projects.

9.7 In addition to the value for money case for accelerating the tackling of the legacy, there is also the ethical case for not leaving a large liability for future generations. A pragmatic reason would be to assist in legitimising new nuclear build. However, these are highly constrained times for public spending, and the case for further acceleration will need to be balanced against other competing demands, even though there are powerful reasons for regarding public sector decommissioning as a special case.

Reprocessing

9.8 The continued commitment to reprocessing spent fuel has led to much higher costs of spent fuel and waste management than would have been the case if spent fuel storage had been introduced when it became apparent that its costs would be much lower. Nothing has changed in terms of the economics of reprocessing: uranium remains plentiful, while the relative costs of reprocessing and storing spent fuel overwhelmingly favour storage. Commitment to extensions to THORP's lifetime is very unlikely to offer good value for money and the economics of any new reprocessing plant would be exceptionally unfavourable. Extensions to currently contracted domestic reprocessing would add greatly to the cost of future decommissioning and waste management, and would therefore be uneconomic for any new build programme. This means that Government's expectation that any new-build programme will be based on a once-through fuel cycle (spent fuel storage) is right. However the issue of the desirability of developing a new MOX plant as a potentially effective waste management option for plutonium already separated is a quite different issue.

Setting out the nuclear liability more clearly

9.9 The presentation of the total costs of NDA's future clean-up work could be enhanced, and the scale of task made clearer, by adding to the financial data currently made public. At present only the discounted value of liabilities is published. This is necessary and valuable information but does not show the magnitude of the task, nor the progress made to date. Presentation of the undiscounted value of the liability, expressed net of general inflation, would show both magnitude and (over time) progress much more clearly. The current presentation of the liability only in discounted form, without correcting for inflation, tends to show annual increases in liabilities for artificial reasons. These are the effect of general inflation and the unwinding of a year's discounting, the latter raising, for purely technical reasons, the apparent value of future work. Changes in the applicable discount rate can also lead to changes in the apparent size of the liability, again for essentially technical reasons. As the 2010/11 ARA of the NDA makes clear, a shift in the approved discount rate by 0.5% point would change the discounted value of the liabilities by £5.5 bn. Presentation in undiscounted form would avoid these problems and allow the NDA more easily to show progress made in each year's liability discharge.

9.10 Another lesson concerning the information available on the future scope of clean-up work has already been introduced in the most recent ARA of the NDA. This is the presentation of the future liability cost in the form of a range of possible values around a ‘most likely’ estimate. The 2010/11 accounts show a range of £46.1 billion to £57.5 billion in discounted liability, around a most likely value of £49.2 billion, thus showing a higher risk of the eventual bill being higher than the ‘most likely’ estimate than lower. Greater transparency around a most likely undiscounted value might help broaden public understanding of the scale of the legacy.

9.11 However, fully transparent accounting is difficult for the NDA because it retains responsibility for commercial activity which it is sometimes difficult to separate wholly from liability management, especially at Sellafield which is a complex and highly interdependent site. Nevertheless there would be value in having some finer-grained information available. In general, a better separation of commercial from liability management costs would be valuable, wherever this is feasible. Two more specific examples are: it would be useful if support and overhead costs, currently running at over £500 million annually (and subject to an initially successful campaign of reduction), could be attributed to specific sites,- where site-related - as well as to other functions. We understand that NDA is already working on this area; and more detail on new construction costs, especially as between commercial and liability management projects, would also help.

The Nuclear Liabilities Fund (NLF) and new nuclear

9.12 The current regime controlling the investment policy of the NLF, where funds are placed in the currently low-yielding National Loans Fund provides the short-term national benefit of reducing short-term borrowing but increases the long-term risk that the fund may not cover all the liabilities. Segregated funds are a necessary but not always sufficient basis for financial robustness. Current Government work on establishing a liability funding regime for any nuclear new-build seems to have learned relevant lessons from past funding regimes.

9.13 The funding of UK nuclear liabilities is currently subject to two distinct regimes, the NDA for the legacy, and the NLF for BE liabilities. A third is in process of being added as Government moves towards a new system for new-build nuclear power. There are already connections between the two existing systems in relation to decommissioning facilities, especially the role of the NDA in both. It is also the case that there are several reactor sites where the NDA and BE are ‘over the fence’ from each other. There are already some elements of co-operation between the two organisations (beyond NDA’s statutory role in assessing BE’s decommissioning plans) and further consideration should be given to extensions of co-operation as a route to better value for money, for example in considering shared waste facilities. The Government’s current plans include an incentive structure which supports such cooperation, as well as active management of the legacy by any new nuclear operators.

MACKERRON EVALUATION – ANNEXES TO REPORT

A1 Glossary of abbreviations

A2 Note on scope of the evaluation and terminology

A3 Chronology of key events

A4 Table and chart of accounting provisions for decommissioning

ANNEX 1

Glossary of Abbreviations

ADL	Arthur D Little
AGR	Advanced Gas Cooled Reactors
APC	Atomic Power Construction
ARA	Annual Report and Accounts
BE	British Energy
BNFL	British Nuclear Fuels Limited
BNG	British Nuclear Group (in BNFL)
BWR	Boiling Water Reactor
CEGB	Central Electricity Generating Board
CoRWM	Committee on Radioactive Waste Management
CSR	Comprehensive Spending Review
DECC	Department of Energy and Climate Change
DTI	Department of Trade and Industry
EARP	Enhanced Actinide Removal Plant
EDF	Electricite de France
EYF	End Year Flexibility
FBR	Fast Breeder Reactor
FFL	Fossil Fuel Levy
GDF	Geological Disposal Facility
HLW	High Level Waste
IAEA	International Atomic Energy Agency
ILW	Intermediate Level Waste
kW	Kilowatt-hour
LLW	Low Level Waste
LMA	Liabilities Management Authority
ME	Magnox Electric
MOX	Mixed Oxide
MW	Megawatt
NAO	National Audit Office
NDA	Nuclear Decommissioning Authority
NEA	Nuclear Energy Agency (of the OECD)
NII	Nuclear Installations Inspectorate
NFFO	Non-Fossil Fuel Obligation
NLF	Nuclear Liabilities Fund
NLIP	Nuclear Liabilities Investment Portfolio
OECD	Organisation for Economic Co-operation and Development
ONR	Office of Nuclear Regulation
PBO	Parent Body Organisation
PWR	Pressurised Water Reactor
QQR	Quinquennial review
R&D	Research and Development
RCEP	Royal Commission on Environmental Pollution
REC	Regional Electricity Company
RWM	Radioactive Waste Management
SIXEP	Site Ion Exchange Effluent Plant
SLC	Site Licence Company

SN	Scottish Nuclear Limited
SoS	Secretary of State
SR	Spending Review
SSEB	South of Scotland Electricity Board
THORP	Thermal Oxide Reprocessing Plant
UKAEA	United Kingdom Atomic Energy Authority

ANNEX 2

Scope of the evaluation and terminology

1. The title of the lead agency in this area, the **Nuclear Decommissioning Authority**, can give an impression that the main issue is the return of nuclear sites to alternative uses via the removal of the radioactive and other structures they contain. While this is a central part of the NDA remit, the NDA has a wider responsibility than decommissioning in this narrow sense, as it is also charged with responsibilities for radioactive waste management. It is worth noting that the original title of this body was the Liabilities Management Authority, embracing the idea that all long-term nuclear liabilities would be managed in a unified way.

2. The terms of reference for this study start by saying that coverage is to be of:
   "….the history of the UK approach to funding nuclear decommissioning, waste management and clean-up."
   It is worth looking at the various terms that are used in this broad area, getting some working definition of them, and locating where this study falls within them.

3. Starting with broader and least technical, the first term is **clean-up**, an idea which refers to work designed to remediate the potentially damaging side-effects (broadly negative externalities, in economics language) of nuclear activities. It is a term close to the spirit of the present project. Clean-up refers not only to the processes of decommissioning and management of solid wastes, but also to operational issues in the management of wastes. In the 1980s for example, BNFL invested large sums in plants (SIXEP and EARP) to reduce the radioactive content of liquid waste streams which it discharged into the Irish Sea. This is an important part of the management of wastes. Expenditures of this kind, whether historic or prospective, are part of the clean-up and the funding of them is in principle included in this study.

4. Second, reference is often made to the **nuclear legacy**, clearly a time-related idea. This term is frequently used in the area of radioactive waste management (RWM) where the distinction is made between legacy waste, meaning the waste which either currently exists or which is more or less inevitably to be created in the near future as a consequence of past decisions, and new build waste – where the reference is to wastes that will arise if and when new nuclear power stations are built. Generally, if implicitly, the idea of the legacy refers to solid forms of waste, or at least to forms of waste that may currently be liquid but which may be solidified (e.g. by vitrification) at some future point..

5. The third term is **liabilities**, which is an accounting term that may refer to many types of cost generated in any kind of economic activity. The distinction between a liability and a routine cost is that a liability is a

financial consequence of past activity. Most liabilities are 'long-term' (strictly falling due to be met in more than one year's time) and are therefore not expected to be met in the course of normal operational activity. In the nuclear area, it is often argued that substantial liabilities can only be met ('discharged') a very long time into the future, often during periods when there will be no corresponding operating income to pay for them, or assets that can be sold for the same reason. The conclusion is then that a long-term funding arrangement needs to be put in place in the short term to guarantee that the liability costs will be covered when they fall due. This is sometimes related to the broad environmental 'polluter pays' principle that the generation responsible for creating a liability should also be responsible, at least financially, though not always physically, for its discharge.

6. It is sometimes argued (and sometimes implicit) that nuclear liabilities are inevitably going to be of a long-term nature for broadly technical reasons. The timing of the liability discharge process is however not necessarily technically fixed or always very long-term. In UK usage, there are three **main categories of nuclear liability: decommissioning, waste, and spent fuel management** (usually in the latter case including reprocessing). Decommissioning is often expected to take 100 years or more to complete, wastes may need to be managed over even longer periods and spent fuel may need to take decades to be reprocessed and the resultant wastes managed. However:

   - the delay to decommissioning is a policy decision (the NDA have suggested the possibility of truncation from 100 to 25 years in the past);
   - the issue of long-term management of higher activity wastes was officially postponed for 50 years back in 1982, largely because of the political difficulty of securing agreement on a long-term management strategy; and
   - spent fuel costs are often postponed because of technical difficulties in getting reprocessing plants to keep up with spent fuel volumes.

   However, some spent fuel costs are managed in the relatively short term (for some reprocessing and for storage of wastes and spent fuel) and some further waste costs are met out of revenue in the short term, as in the case of low level wastes sent for burial near Drigg.

7. So what is included in 'liabilities' is not always clear-cut - even with the expectation of delays, not all waste and spent fuel management costs are 'liabilities' and their scope depends on policy decisions. The scope of liabilities is generally somewhat larger in the UK than in most other nuclear countries, and there has been evidence that the nuclear industry and Government have been in favour of postponement of costs and their placement in the 'liability' category for reasons of minimizing shorter term costs and accounting provisions. We are interested for this study in a wider idea than liabilities – for example we include SIXEP/EARP and low

level RWM costs, both of which are in the clean-up, but not the liability category.

8. **Wastes**, an apparently (but not actually) unambiguous physical category, are clearly of major interest to this study. They are a more limited idea than liabilities in some respects (they do not include the process of decommissioning nuclear sites). There is a variety of classification schemes for waste. In the UK the categories are low level, intermediate level and high level wastes (LLW, ILW and HLW), depending on the level of radioactivity and (in the case of HLW) its characteristic of continuing to generate heat for many years.

9. Materials are classified as wastes when there is agreement that they have no potential future economic uses at current or expected level of costs and state of technology. Examples of low level waste are clothing and glove boxes used by operators at plants like Sellafield and some of the concrete from decommissioning reactors and such material – large in volume but low in radioactivity – is buried in a shallow disposal site near Drigg. Examples of intermediate level wastes are materials routinely arising in reactor operations (e.g. fuel cladding) and some that result from the reprocessing of spent fuel. These are substantially smaller in volume but sufficiently radiotoxic that they require careful, shielded storage and are expected to be disposed in deep geological repositories, other than waste in Scotland – the Scottish Government does not support this option and therefore ILW in Scotland will not, on current policies, be disposed of in a GDF. High level, heat generating wastes, are very small in volume but both highly radiotoxic and often very long-lasting in terms of potential for harm. In the UK the main category of HLW has been the liquid nitric acid-based material resulting from reprocessing (highly active liquors or HAL).

10. All the examples above are regarded more or less universally as wastes. However there are other categories of radioactive materials about which there is controversy, and differences in classification in different countries, and potentially over time. In the UK, the separated **plutonium** and **uranium** extracted as a result of spent fuel reprocessing has traditionally not been classified as a waste, in recognition of the possibility that these materials could be used in the manufacture of future nuclear fuel – though to date no such use has been made of the the UK-owned stocks . Equally, spent fuel, some of which (from AGR reactors) is currently stored pending long-term management decisions, has also not been classified as waste. The terms of reference for CoRWM did, however, require consideration of the management of plutonium, uranium and spent fuel as potential future wastes.

11. In most nuclear-using countries, reprocessing of spent fuel is not undertaken, which means that spent fuel (containing plutonium and unfissioned uranium) is classified and treated as waste. The classification makes a significant difference to the expected liability costs – classifying plutonium as waste, with an expectation of some kind of disposal, would add several billion pounds to the overall liability bill in the UK. Current possibilities, such as using the plutonium stockpile to make mixed oxide

fuel (MOX, involving a combination of plutonium and natural uranium) might reduce this bill but MOX fuel will be more expensive to make and use than uranium only fuel.

12. This study is clearly interested in principle in the cost and funding of all three categories (LLW, ILW and HLW), though LLW is relatively inexpensive to manage and the great bulk of it has generally not been treated as a liability. We are also interested in principle in the funding of storage of reprocessed plutonium and uranium, as well as spent fuel, because they all carry some level of future liability.

13. So far the discussion has implicitly treated all wastes as if they were solids. However many wastes arise in the first instance as **gases or liquids**. Routine gaseous discharges tend to be small in radioactivity terms and are closely regulated. Generally it is not believed that they pose hazards to human health as presently regulated and they are not considered in this study. However many radioactive waste streams arise in liquid form. In general, radioactive wastes are more easily managed when in solid rather than liquid form and several liquid wastes are routinely turned into solids, for example the liquid nitric acid from reprocessing is eventually vitrified (turned into glass blocks). But some liquid wastes are discharged into the environment, usually the sea. In the late 1970s and 1980s the radioactivity in liquid discharges from Sellafield into the Irish Sea rose and the result was substantial expenditure on plants designed to reduce this level of radioactivity substantially prior to discharge. This study is therefore interested in the funding of these treatments to liquid wastes.

14. The final term, already referred to, is **discharges**, which are generally gaseous or liquid. A radioactive discharge is by definition a waste form of some kind. The funding associated with it may be trivial or non-existent, as in the case of routine gaseous discharges, but there may often be a cost associated with discharges, especially with liquid wastes, either prior to their release into the environment or in the course of turning them into more tractable solids. As a category of wastes, this study is clearly interested in the funding associated with discharge management.

ANNEX 3

Chronology of significant dates

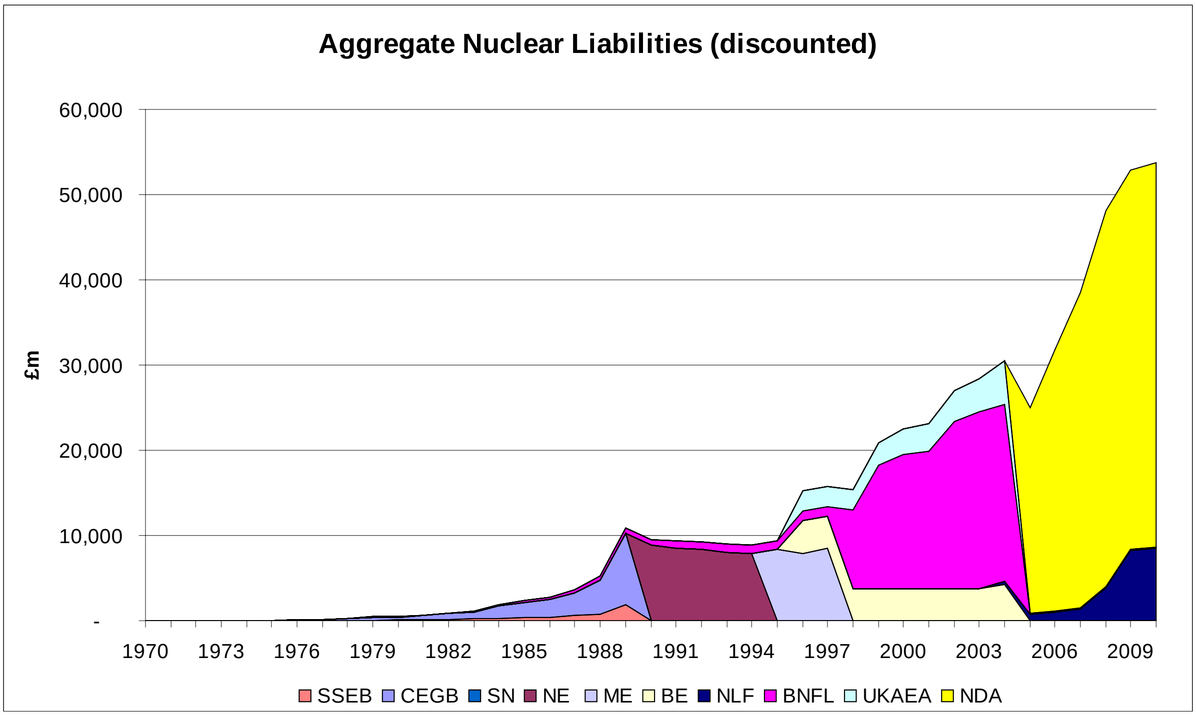
1954	Establishment of the UKAEA Construction of first Dounreay Fast reactor
1956	Calder Hall opened by Queen
1959	Licensing of Dounreay waste shaft
1965	Decision to opt for the AGR in second reactor programme
1971	BNFL created
1976	Flowers Report raises the issue of waste management
1977	Windscale Enquiry
1982/3	Sea dumping suspended, following international pressure
1982/5	Sizewell Enquiry
1988	Fast Reactor Programme scaled back
1989 - 1990	Privatisation of electricity supply industry, announcement of withdrawal of Magnox (July 1989) and AGRs and PWR (November 1989) from privatisation.
1990	Fossil Fuel Levy established
1994	UKAEA becomes effectively a legacy management organisation
1996	Privatisation of British Energy, and establishment of NDF,
1997	Nirex Enquiry
1998	Magnox Electric transferred to BNFL. £2.6 billion from fossil fuel levy used to endow Nuclear Liabilities Investment Portfolio (NLIP)
1999	BNFL purchase of Westinghouse
1999-	Review of liabilities establishes that they are

2000	major barrier to sale of BNFL – estimated at £34 billion. NLIP now exceeds £4 billion
2001	Quinquennial Review of the UKAEA proposes the establishment of an LMA to manage nuclear liabilities.
2001	Patricia Hewitt Commons Statement announced Government will create LMA
2002	Publication of White Paper *Managing the Nuclear Legacy*
2004	Passing of the Energy Act
2004	Rescue of British Energy, following collapse in the electricity price.
2005	Establishment of the NDA
2005 - 9	Wind down of BNFL, with assets sold off piece by piece. The sale of Westinghouse raises £4 billion.
2006	Nirex absorbed into the NDA
2007	Letting of the Sellafield contract
2008	Restructured British Energy sold to EDF, with most of proceeds used to endow NLF
2010	Spending Review
Now	
Next 2 years	End of Magnox generation (currently Wylfa and one Oldbury reactor remain operational)
Next 10 years	End of Magnox reprocessing (current plan 2016) and THORP reprocessing (current plan 2020)
2023	All AGR stations will have ceased operations under current plans (EDF expected to apply for lifetime extensions)
2034	All Magnox sites in care and maintenance

2040	Deep Geological Disposal Facility available
2101	All Magnox sites cleared
2120	Final Sellafield site clearance (under current lifetime plan) – will depend on future development of nuclear industry

Annex 4: Decommissioning Provisions

The table and chart below set out the provisions made by each of the organisations involved in the UK nuclear industry for decommissioning. The figures used are those provided in each company's annual reports. These are not fully comparable, as the discount rates used are not consistent, many of the companies did not publish an undiscounted figure, and the rates of discounting, and profile of intended expenditure are not all now available. Nevertheless, the chart and table below do summate the collective provisions made, to provide the best general indication which can now be made of increase in nuclear provisions from 1970 to the present – and the overall profile presented by the chart is a realistic picture.



Cumulative provisions for decommissioning costs by organisation (discounted)

£ m	SSEB	CEGB	SN	NE	ME	BE	NLF	BNFL	UKAEA	NDA	Total
1970	2										**2**
1971	3										**3**
1972	3							-			**3**
1973	3										**3**
1974	3							7			**9**
1975	3	34						9			**45**
1976	4	67						11			**83**
1977	10	149						13			**172**
1978	26	233						47			**306**
1979	37	367						55			**459**
1980	65	333						73			**472**
1981	99	464						76			**640**
1982	158	658						85			**902**
1983	233	791						153			**1,177**
1984	296	1,432						194			**1,921**
1985	357	1,791						250			**2,398**
1986	407	2,038						314			**2,759**
1987	645	2,635						375			**3,656**
1988	755	3,993						466			**5,214**
1989	1,818	8,454						552			**10,824**
1990				8,831				675			**9,506**
1991				8,529				800			**9,329**
1992				8,314				902			**9,216**
1993				8,033				967			**9,000**
1994				7,825				1,000			**8,825**
1995					8,423			1,014			**9,437**
1996					7,888	3,889		1,120	2,294		**15,191**
1997					8,470	3,733		1,196	2,355		**15,754**
1998						3,786		9,153	2,402		**15,341**
1999						3,790		14,418	2,650		**20,858**
2000						3,762		15,786	2,967		**22,515**
2001						3,770		16,106	3,288		**23,164**
2002						3,728		19,676	3,647		**27,051**
2003						3,719		20,736	3,880		**28,335**
2004						4,223		20,758	5,071		**30,052**
2005							2,000		139	24,093	**26,232***
2006							3,200		160	30,575	**33,935**
2007							3,389		153	37,036	**40,578**
2008							3,841		166	44,100	**47,762**
2009							3,561		154	44,504	**48,219**
2010							3,934		164	45,083	**49,181**

* £5bn of 'consolidation adjustment' (when BNFL, UKAEA and MoD assets were merged into NDA)

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